In addition to the estimated contribution to the regional economy associated with repository workers, DOE is responsible for Payments-Equal-To-Taxes (PETT) pursuant to Section 116(c)(3)(A) of the NWPA, which requires the Secretary of Energy to "…grant to the State of Nevada and any affected unit of government, an amount each fiscal year equal to the amount such State or affected unit of government, respectively, would receive if authorized to tax site characterization activities…." Clark County has been eligible to receive PETT since the enactment of the amendments Nuclear Waste Policy Amendments Act of 1987 (Public Law 100-203, 101 Statute 1330).

DOE acquires data from the Yucca Mountain Site project organizations that purchase or acquire property for use in Nevada, have employees in Nevada, or use property in Nevada. These organizations include Federal agencies, national laboratories, and private firms. Not all of these organizations have Federal exemption status so they pay the appropriate taxes. The purchases (sales and use tax), employees (business tax), and property (property or possessory use taxes) of the Yucca Mountain Project organizations that exercise a Federal exemption are subject to the PETT Program (DIRS 103412-NLCB 1996).

The actual sales and use taxes, property taxes, and Nevada business taxes paid by Yucca Mountain Project organizations that were not exempted from tax payment obligations for the period from May 1986 through June 2000 have been calculated. These organizations paid sales and use taxes of $2.5 million for purchases made in Clark County; paid property or possessory taxes of about $90,000 in Clark County; and paid the State of Nevada about $810,000 in business taxes (DIRS 156763-YMSCO 2001). The PETT for sales or use taxes from May 1986 through June 2000 was about $4.4 million for purchases in Clark County. For property taxes, it was about $940,000 in Clark County; about $130,000 was paid to the State of Nevada in business taxes.

7.5.7 HUMAN HEALTH AND SAFETY

7.5.7 (66)
Comment - 15 comments summarized
Commenters were both for and against DOE's methods for estimating radiation health impacts from low-level exposure to radiation, methods that are based on the linear no-threshold hypothesis. Several commenters thought use of the linear no-threshold hypothesis was too conservative, noting the extrapolation of observed high dose and effect relationships to low doses, where no effects have been observed, and the possibility of positive effects (radiation hormesis). One commenter noted the opposing "supralinearity" hypothesis, which theorizes higher effects at low doses. Other commenters noted the general acceptance of the linear no-threshold hypothesis and its implication that all radiation exposure carries with it some degree of risk. Some commenters suggested DOE needed to reconsider models used for the dose-health effect relationship.

Response
DOE recognizes there are uncertainties regarding the relationship of radiation dose and health effects at low doses and low dose rates. Scientific advisory groups, including the National Academy of Sciences, National Council on Radiation Protection and Measurements, and the International Commission on Radiological Protection have reviewed the research and population exposure data and recommended methods for calculating dose and estimating exposure effects. These organizations recognize that the use of dose-to-risk conversion factors based on the linear no-threshold hypothesis to estimate stochastic effects (latent cancer fatalities, nonfatal cancer incidence, and hereditary effects) from very low exposures to ionizing radiation may overestimate the actual risk. DOE also recognizes that experts in the scientific community are reviewing the merits of the linear no-threshold hypothesis. However, because of uncertainties in the low dose/low dose rate region of the dose-health effect curve, the dose-to-risk conversion factors recommended by the National Council on Radiation Protection and Measurements (DIRS 101856-NCRP 1993) and the International Commission on Radiological Protection (DIRS 101836-ICRP 1991) for estimating the risk from exposure to ionizing radiation are based on the linear no-threshold hypothesis. These organizations have been careful to point out over the years that the use of the linear no-threshold-derived risk factors will provide reasonable assurance that the actual effect will not be underestimated. For these reasons, the linear no-threshold hypothesis has been accepted for use by federal agencies—including DOE, the Environmental Protection Agency, and the Nuclear Regulatory Commission—for radiation protection and for estimating risk from exposure to ionizing radiation.

Although human response to radiation exposure has been extensively studied for over 75 years, there is still much that is unknown about effects of chronic exposure to low level radiation. This is why, in 1998, the Environmental

Protection Agency and DOE called on the National Academy of Sciences-National Research Council to reconvene the Committee on Health Risks from Exposure to Low Levels of Ionizing Radiation to analyze the large amount of published data since the last Committee report (DIRS 100473-National Research Council 1990) was published. The committee will consider relevant data derived from molecular, cellular, animal, and epidemiologic studies in its comprehensive reassessment of the health risks resulting from exposures to low-level ionizing radiation.

In 1995, the National Academy of Science/National Research Council Committee on and Assessment of CDC Radiation Studies stated the following (DIRS 100018-National Research Council 1995):

"From the beginning of time, humans have lived in a "sea of radiation," namely that which results from natural background (cosmic and terrestrial radiation, and naturally occurring radionuclides in out air, water, and food). The accompanying dose rates are estimated (NCRP, Report 93) to be three times the current dose rate limit for members of the public. If exposures to these sources have led to any significant health effects, humans would never have been successful in reaching their current stage of development."

The report went on to say (DIRS 100018-National Research Council 1995):

"Traditionally, radiation protection guidelines are predicated on a linear dose response, which assumes that the harmful effects of radiation are linearly related to the dose and that there is no threshold dose. Most experts believe this assumption is conservative; that is, it overestimates the effects of ionizing radiation at low doses because it ignores the potentially beneficial effects of the body's repair mechanisms [radiation hormesis]."

For these reasons the Committee on Health Risks has been charged with, among other things, assessing the current status and relevance to risk models of biological data and models of carcinogenesis, including critically assessing all data that might affect the shape of the response curve at low doses, in particular, evidence of thresholds or the lack thereof in dose-response relationships and the influence of adaptive responses and radiation hormesis.

DOE joins the charge to the Committee, namely that there is a need for a critical assessment of all biological data that could affect the shape of the dose/response curve at low doses. The outcome of this review might (1) confirm the linear no-threshold hypothesis; (2) confirm the evidence that there is a threshold below which no harmful effects occur; or (3) show that there are beneficial effects in the low dose regime. Because of the need to ensure that our radiation protection standards are adequate, and that we are not spending money on nonexistent problems, DOE believes that that such a review is timely. Although beneficial effects of low-level radiation could be one of the outcomes of the study, any such effects will not be known to exist until the committee completes its studies and issues its report in 2003.

7.5.7 (93)
Comment - 39 comments summarized
Commenters expressed concern about the potential for cancer and other health effects caused by exposure to ionizing radiation from the repository.

Response
DOE recognizes that the risk of cancer and other health effects caused by exposure to ionizing radiation is of concern to many citizens. Thus, in addition to keeping radiation doses within Environmental Protection Agency *Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada* (40 CFR Part 197), and Nuclear Regulatory Commission licensing criteria (10 CFR Part 63), DOE is committed to keeping radiation doses from Yucca Mountain-related preclosure activities to levels that are as low as is reasonably achievable. For example, in the vicinity of the repository (the area within 50 miles), DOE estimates short-term impacts from construction, operation and monitoring, and closure of the proposed repository would result in less than 2 millirem per year to the maximally exposed member of the public (see Table 4-34 of the EIS). This exposure is less than 15 percent of the 15 millirem limit promulgated at 40 CFR 197.4 and 10 CFR 63.204 and less than 1 percent of the annual 200-millirem dose to members of the public in Amargosa Valley from background levels of naturally occurring radon-222 and its decay products. For the flexible design, for the first 10,000 years after repository closure, the mean peak annual dose to the reasonably maximally exposed individual would be thousands of times less than the individual protection standards at 40 CFR 197.20 and 10 CFR 63.311, which allow up to

15-millirem-per-year dose rates during the first 10,000 years (see Table 5-6). The peak doses would be even smaller at greater distances.

The EIS provides estimates of lifetime doses and potential additional fatal cancers for entire populations that could be affected by the Proposed Action. For example, DOE estimates that for the lower-temperature operating mode, the potentially affected population within 80 kilometers (50 miles) of the repository (estimated to be 76,000 individuals in 2035), could receive as much as 4,000 person-rem over 341 years of operation, which could result in as many as 2 additional cancer fatalities in the exposed population. This would represent an increase of 0.002 percent of the 89,000 cancer deaths expected to occur from natural causes in the potentially exposed populations over a 340-year period (that is, five 70-year generations). Similar estimates have been made for impacts to populations exposed over 10,000 years (see Table 5-7).

Although low levels of radiation exposure are estimated to result from the proposed action to construct, operate and monitor, and close the proposed geologic repository and the EIS provides estimates of latent cancer fatalities that could result from these small doses, these estimates are provided primarily to inform the decisionmaking process by enabling a quantitative comparison of impacts between the alternatives evaluated in this EIS. In all cases, estimates of latent cancer fatalities resulting from very small doses summarized in the EIS should be viewed as conservatively high; in fact, the uncertainties and conservatisms associated with these estimates (see Sections K.4.3.2 and F.1.1.5) are such that DOE believes that any adverse health impacts resulting from these exposures would be highly unlikely or nonexistent.

7.5.7 (98)
Comment - 35 comments summarized
Commenters noted that the Draft EIS presented only estimates of latent cancer fatalities and no estimates of other health effects. A number of other diseases and effects were listed as concerns, including death, birth defects, genetic damage, nonfatal cancers, immune system depression, visual impairment, mental retardation, spina bifida, female reproductive impairment, premature aging or life shortening, tumors, teratogenic effects, Alzheimer's disease, Parkinson's disease, pulmonary fibrosis, emphysema, and others. Other commenters requested that Appendix F of the EIS (the "radiation primer") provide additional information. Commenters stated that individual members of the population, specifically those with increased sensitivity to radiation such as children or an embryo-fetus, should be evaluated as the hypothetical maximally exposed individual member of the public.

Response
Health effects of radiation exposure can be placed in two categories: stochastic (random) and nonstochastic (deterministic). Stochastic effects are those that have a probability (not a certainty) of occurrence and include somatic effects such as latent fatal and nonfatal cancers, and genetic effects such as hereditary disorders that could occur in the progeny of exposed individuals (that is, future generations). The probability of the occurrence of such effects, not their severity, is affected by the amount of radiation exposure an individual receives. To estimate the probability of occurrence of these effects, DOE used the linear no-threshold hypothesis, which conservatively assumes that every dose, no matter how small, carries some increased risk of fatal cancer.

On the other hand, nonstochastic or deterministic effects occur only after a certain amount of radiation exposure has occurred. These occurrences and the severity of the effects (not the probability of occurrence), which are affected by the amount of radiation exposure an individual receives, include somatic effects such as cataracts, premature aging, infertility, emphysema, and pulmonary fibrosis as well as teratogenic effects in children exposed in-utero such as microcephaly (smallness of the head) and mental retardation. Most of the health effects noted by commenters are nonstochastic and would be unlikely to occur even at doses thousands of times higher than those resulting from the Proposed Action.

DOE recognizes that the risk of cancer and other health effects attributed to radiation exposure are of concern to many citizens. However, for chronic low doses such as those estimated in the EIS to result from the Proposed Action, the National Research Council Committee on the Biological Effects of Ionizing Radiation stated that cancer induction is the most important somatic effect (DIRS 153007-National Research Council 1980). The Committee went on to say that among the somatic effects of radiation other than cancer, developmental effects on the unborn child are of greatest concern (DIRS 153007-National Research Council 1980). In addition, the Committee said that for somatic effects other than cancer and developmental changes (for example, cataracts, aging, and infertility), the available data do not suggest an increased risk with low-dose, low-linear-energy-transfer exposure of human populations (DIRS 153007-National Research Council 1980).

In addition to fatal cancers, as the commenters have suggested, experts generally recognize that other health effects could result from exposure to radiation. Therefore, to enable comparisons with fatal cancer risk, the International Commission on Radiological Protection (DIRS 101836-ICRP 1991) suggested the use of detriment weighting factors that consider the curability rate of nonfatal cancers and the reduced quality of life associated with nonfatal cancers and heredity effects. However, as discussed in Section F.1.1.5 of the EIS, because both of these life detriment factors, taken together, amount to less than half the fatal cancer risk, DOE has chosen to estimate only latent cancer fatalities as the most important health effect from exposure to radiation.

For these reasons, DOE used dose-to-risk conversion factors recommended by the National Council on Radiation Protection and Measurements (DIRS 101856-NCRP 1993) and the International Commission on Radiological Protection (DIRS 101836-ICRP 1991) for estimating the risk of latent cancer fatality from exposure to ionizing radiation. These factors were developed based on the linear no-threshold hypothesis, which assumes that adverse health effects could occur from exposure to ionizing radiation regardless of how small the dose.

However, all types of individuals are included in the radiation risk factor of 1 latent cancer fatality per 2,000 rem of ionizing radiation received by an exposed population (0.0005 latent cancer fatality per rem). Children comprise a relatively large part of the population and are more sensitive to the effects of radiation (cancer induction) than adults. Children are the principal reason the risk factor for the whole population is 25 percent higher than the factor for workers (1 latent cancer fatality per 2,500 rem, or 0.0004 latent cancer fatality per rem).

Other types of individuals, such as pregnant women, the aged, and those with impaired health, are not unduly radiosensitive, especially to the low levels of radiation expected from the proposed activities at the Yucca Mountain site. The embryo-fetus is more radiosensitive than the general population and the radiosensitivity varies with the stage of development. However, the embryo-fetus is not suitable as the hypothetical reasonably maximally exposed individual because:

- The embryo-fetus is exposed for at most 9 months, compared to 70 years of exposure for an individual.
- The body of the mother protects the embryo-fetus. Many radionuclides are either excreted or would first migrate to the organs of the mother. Many particulate radionuclides do not cross the placental barrier.
- There is not an extensive database of scientific information on placental transfer of radionuclides and their concentrations and dosimetry in the human embryo-fetus, and there are a number of unknowns and uncertainties about this information (DIRS 157140-NCRP 1998).

For comparison, the National Council on Radiation Protection and Measurements recommends a dose limit of 50 millirem per month to protect the embryo-fetus of occupationally exposed women (DIRS 101856-NCRP 1993).

DOE has revised the radiation health primer in Section F.1 of the EIS to include an expanded discussion of ionizing radiation and radiation-related health effects. Section 6.3 evaluates the health impacts of transporting waste by truck or rail in Nevada, including accidents.

7.5.7 (105)
Comment - 11 comments summarized
Commenters suggested that DOE should conduct a baseline health assessment in the 10 affected counties. This assessment would determine what types and frequencies of health effects are currently occurring in affected counties. Commenters stated that by showing the present health situation, a case might be made for not adding to a potential number of latent cancer fatalities, and for documenting current health conditions before an occurrence of a radioactive waste accident. Other commenters were concerned about compensation in a timely manner in the event of an accident.

Response
DOE believes that a baseline health assessment is unnecessary for the Yucca Mountain Repository because adverse health impacts from the Proposed Action would be highly unlikely. For example, in the vicinity of the repository [the area within 80 kilometers (50 miles)], DOE estimates short-term impacts from construction, operation and monitoring, and closure of the proposed repository would result in less than 2 millirem per year to the maximally exposed member of the public (see Table 4-34 of the EIS). This exposure is less than 15 percent of the 15-millirem limit promulgated at 40 CFR 197.4 and 10 CFR 63.204 and less than 1 percent of the annual 200-millirem dose to members of the public in Amargosa Valley from background levels of naturally occurring radon-222 and its decay products. For the flexible design, for the first 10,000 years after repository closure, the mean peak annual dose to the reasonably maximally exposed individual would be thousands of times less than the individual protection standards at 40 CFR 197.20 and 10 CFR 63.311, which allow up to 15-millirem-per-year dose rates during the first 10,000 years (see Table 5-6). The peak doses would be even smaller at greater distances.

The EIS provides estimates of lifetime doses and potential additional fatal cancers for entire populations that could be affected by the Proposed Action. For example, DOE estimates that for the lower-temperature operating mode, the potentially affected population within 80 kilometers (50 miles) of the repository (estimated to be 76,000 individuals in 2035), could receive as much as 4,000 person-rem over 341 years of operation, which could result in as many as 2 additional cancer fatalities in the exposed population. This would represent an increase of 0.002 percent of the 89,000 cancer deaths expected to occur from natural causes in the potentially exposed populations over a 340-year period (that is, five 70-year generations). In all cases, these risks have been shown to be very low and, considering the conservatisms used in these estimates, probably nonexistent. DOE believes that even if large-scale health studies were conducted, the identification of adverse health impacts resulting from the Proposed Action would not be discernible.

In the event of actions that compromised the integrity of the repository, mitigation activities would be funded under either the Nuclear Waste Fund or the Price-Anderson Act. The Price-Anderson Act provides liability coverage for commercial activities operating under a license from the Nuclear Regulatory Commission and DOE activities. It establishes a system of private insurance and Federal indemnification that generally ensures that up to $9.43 billion is available to compensate for damages suffered by the public from a “nuclear incident,” regardless of who causes the damage. Payment would be from government funds or, if public liability arose out of nuclear waste activities funded by the Nuclear Waste Fund (for example, activities at a geologic repository), from that fund. The liability of all responsible parties is limited to the amount of coverage provided by the Price-Anderson system. State and local governments cannot be required to provide any additional compensation. The EIS has been revised to include more details about indemnification under the Price-Anderson Act (see discussion in Section M.8).

Price-Anderson indemnification would apply to the operators of a nuclear waste repository at Yucca Mountain (which would also be licensed by the Nuclear Regulatory Commission pursuant to the NWPA) and to transporters of nuclear waste from commercial nuclear utilities and from DOE sites to the repository. Thus, Price-Anderson liability coverage extends to DOE contractors that manage and conduct nuclear activities in the DOE complex. In a general sense, the Federal Government acts as an insurer for these contractors against any findings of liability arising from the nuclear activities of the contractor within the scope of the contract.

7.5.7 (235)
Comment - 11 comments summarized
Several commenters were concerned about the magnitude of the radon release from the repository in ventilation air, and about the potential for radiation dose to workers – especially during construction – and members of the public. The use of a 20 km distance for the maximally exposed member of the public was questioned. Other commenters noted that the SDEIS should provide an assessment of the impacts associated with increased ventilation from the repository under the flexible design operating modes.

Response
Radon-222 is a ubiquitous, naturally occurring noble gas. It accounts for greater than 99 percent of the radiation dose to the public from repository activities, because only very small quantities of manmade, noble gas radionuclides would be released from spent nuclear fuel handling activities (Section G.2.3.2). Radon itself has very little dose potential because it is a noble gas and does not deposit or bind to other substances or tissue. Nearly all of the potential for radiation dose comes from its decay products. Most of the concern for radon exposure comes from

the buildup of radon and its decay products in enclosed spaces where there is little ventilation to remove these radionuclides to the outside air and people can inhale them. That is why the Environmental Protection Agency has established guidelines for radon in indoor air and particularly applicable to living spaces such as basements. It is estimated that the average annual dose from inhalation of radon and its decay products is 200 millirem in the United States (Section 3.1.8).

DOE recognizes the potential for radon exposure to workers in the underground facilities and also recognizes the need for good ventilation conditions to minimize this exposure. The potential dose from radon and radon decay products to both surface and subsurface workers is discussed in Appendix F of the EIS and included in results shown in Section 4.1.7. Except during construction, when there would be no spent nuclear fuel in the repository, exposure to radon is a very minor component of the worker radiation dose. Radiation doses to workers during the construction phase would be very low, with potential impacts expected to be small (see Section 4.1.7.2). The dose from radon and radon decay products to a subsurface worker is estimated to be about 50 millirem per year for 2,000 working hours underground. As 2,000 hours is about 22 percent of the 8,760 hours in a year, workers would probably receive about 45 millirem from naturally occurring radon if they were not working underground. However, the EIS conservatively assumes that all of this 50 millirem dose as part of the occupational dose. The additional dose from radon to surface workers very small (see Section 4.1.2).

The ventilation conditions in the repository to remove heat from the waste packages under the flexible design operating modes also provide good ventilation conditions for workers. These ventilation conditions also provide the potential for more radon to be released from the repository and potential for exposure to members of the public. The EIS analyses examined all ventilation pathways releasing radon from the repository during all project phases. The maximally exposed individual located 20 kilometers (12 miles) south of the repository would receive a total dose of about 30 millirem over a 70-year lifetime from Yucca Mountain activities. The maximum annual dose would be less than 2 millirem, which would be less than 1 percent of the average annual 200 millirem dose in the United States from exposure to naturally occurring radon. Members of the public would not be able to continuously reside closer than this to the repository because DOE would withdraw the area around the repository from public use and access (see Chapter 3). The potential dose to members of the public visiting the repository would be very small. Even if they spent 2,000 hours a year at the repository their maximum annual dose would only be about 2 millirem, the same as that for the maximally exposed noninvolved worker.

Discussion of radon exposure of workers is provided in Appendix F.1.1, and radon exposure to members of the public is discussed in Appendix G.2.

7.5.7 (236)
Comment - 3 comments summarized
Several comments were made about the potential for pinon pine nuts to accumulate radionuclides and expressed concern that their consumption could represent a potentially unevaluated exposure pathway to humans. One comment also noted the commercial growth of pistachio nuts in the Amargosa Valley and their consumption as well.

Response
Pinon pine trees occupy over 50 million acres in the western United States, primarily in Nevada, Utah, Arizona, Colorado, and New Mexico. They are the dominant overstory tree species around Las Alamos National Laboratory, where researchers have examined the concentration of radionuclides in pinon pine nuts (DIRS 156058-Fresquez et al. 2000). Pinon pine nuts are produced irregularly in nonannual cycles about every seven to ten years. Nonedible portions of plants (roots, stems, and leaves) generally contain higher radionuclide concentrations than the edible tissues (fruiting bodies) of the same plant species. The Los Alamos researchers found this to be true of pinon pines as well, finding radionuclide concentrations higher in pinon pine shoots than in pinon pine nuts. Soil-to-nut concentration ratios (the concentration in nuts divided by the concentration in soil) for most radionuclides were within the range of default values found in the literature for common fruits and vegetables. For potential radionuclide releases from the Yucca Mountain repository to groundwater, only those pinion pines and other nut-bearing trees located down-gradient from the repository and that are irrigated or at a location where groundwater is naturally near the surface could be affected by repository releases. Atmospheric releases of noble gases during repository operations would be minor sources of radionuclides. While the Los Alamos researchers did not examine all of the radionuclides of interest for the Yucca Mountain project, their findings are consistent with the current Project understanding that concentrations of radionuclides in pinon pine nuts -- and other types of locally grown nuts

including pistachios -- represent a relatively minor source of radiation exposure to the public. When the relative quantities consumed are compared for nuts and other more commonly consumed fruits and vegetables, nuts would likely be a minor contributor to the ingestion dose pathway and the overall dose received. The limited areas of potential exposure and multiyear cycling of pinon pine nut production would also reduce the contribution to Native American traditional diets, which could include larger quantities of pinon pine nuts.

7.5.7 (384)
Comment - EIS000048 / 0004
The surrounding areas have no protection from spills and accidents on [the repository] site.

Response
Before beginning repository operations, DOE must have systems in place to prevent and mitigate spills/releases. Because the spent nuclear fuel and high-level radioactive waste would be solid material, the potential for spills would be very small, with the risk of spills mainly associated with liquids and fluids such as those used in any industrial operation.

The following sections of the EIS discuss the measures and plans DOE would use to protect onsite and offsite areas from spills or accidents at the repository site:

- Section 4.1.3.1 discusses the approaches DOE would follow during preconstruction testing and performance confirmation activities to minimize the effects on groundwater of potential releases of hazardous materials.

- Sections 4.1.3.2 and 4.1.3.3 contain discussions on potential contaminant spread to surface water and groundwater, respectively from construction, operation, monitoring and closure of the repository. The discussions include hazardous liquid materials that DOE would store or use on the site, the potential for release of the materials as a result of a spill, and the measures that DOE would institute to prevent their spread during construction, operation and monitoring, and closure.

- Section 4.1.4.4 contains a discussion on "Contamination" that describes how DOE would clean up and dispose of soils contaminated by radiological or nonradiological hazardous materials.

- Section 4.1.8.1 discusses onsite radiological accidents. It notes that impact calculations show that the quantities of radioactivity released to the environment and the quantities of material deposited on the ground would be very low and below the Environmental Protection Agency Protective Action Guidelines, so interdiction would not be necessary.

- Section 4.1.8.2 discusses the control of releases of nonradiological hazardous materials in the event of an accident.

- Sections 9.3.3.1 and 9.3.3.2 discuss the mitigative measures that DOE would institute in the event of an onsite spill/release or accident to minimize the spread of the released contaminant (radiological and nonradiological) to or by surface water and groundwater, respectively.

7.5.7 (564)
Comment - EIS000106 / 0003
The EIS also assumes in all its radiation exposure estimates that there's 28,000 -- there will be 28,000 people within a fifty mile radius of Yucca Mountain. You know, Nye County has published population estimates which showed that the county population in fifty miles, which includes Pahrump, will be at least 47,100 in 2010 when this project starts, and this doesn't include the population that's in California or down in Indian Springs. So in the assumption of the 28,000 within a fifty mile radius, the EIS is assuming that the Yucca Mountain project will be imposed on its static -- on a community that's static at a level that the county passed way back in the mid-1990s.

Response
DOE has revised the population baseline for population dose estimates in the EIS. The Final EIS uses the estimated population in 2035 rather than 2000 as in the Draft EIS. Impact estimates for the Final EIS assume that

the 80-kilometer (50-mile) population would be 76,000 individuals. However, Nye County is one of four counties within the 80-kilometer area around Yucca Mountain. Lincoln and Clark Counties in Nevada and Inyo County, California, are the other three. The bulk of the population in this 80-kilometer area would live in Nye County, but the area does not include all of the County. Therefore, the 80-kilometer population and the county population numbers do not match.

7.5.7 (604)
Comment - EIS000127 / 0021
They're talking about pumping a whole lot water out of Jackass Flats to put a lot of concrete linings in and all of these things, but that they're not taking into consideration is that all the water they pump out of Jackass Flats is already radioactive, so they're going to be building the repository out of radioactive concrete.

And they're not addressing that in the impacts; not for the workers; not for us.

What are the effects of making concrete with radioactive water and then expecting it to last for 10,000 years?

Response
DOE would pump water from groundwater wells at the Yucca Mountain Repository site for use in concrete at the repository. The aquifer supplying those wells is part of the Jackass Flats hydrographic basin. Results of the 1997 groundwater sampling and analysis for radioactivity are shown in Table 3-19 of the EIS. Groundwater monitoring at Yucca Mountain has not detected any radionuclides related to human activities.

7.5.7 (663)
Comment - EIS000167 / 0004
There is an obvious parallel between radiation exposure and incidence of cancer. How can we trust DOE when standards of exposure are set so low. When standards are changed to make Yucca Mountain "OK" and those same standards are set to 1 death related to cancer (i.e., radiation exposure) in 1,000 as opposed to the previous 1 in a million. That one human being in a thousand has lost the most precious inalienable right of all, the right to his or her life. Can you as [a] DOE employee help to replace that trust? Not with propaganda but with changes in how you set the standards? You can. You can set the standards at 1 in a million or at 0.

Response
With regard to radiation exposure and the incidence of cancer, as discussed in Sections K.4.3.2 and Section F.1.1.5, the dose-to-risk conversion factors typically used to estimate adverse human health impacts resulting from radiation exposures contain considerable uncertainty. The risk conversion factor of 0.0005 latent cancer fatality per person-rem (or, one latent cancer per 2,000 rem of exposure) of collective dose for the general public typically used in DOE National Environmental Policy Act documents is based on recommendations of the International Commission on Radiological Protection (DIRS 101836-ICRP 1991) and the National Council on Radiation Protection and Measurements (DIRS 101857-NCRP 1993). The factor is based on health effects observed in the high dose and high dose rate region (20 to 50 rem per year). Because health effects in humans have not been observed below acute 10 rem (10,000 millirem) exposures, potential health effects were extrapolated to the low-dose region (less than 10 rem per year) using the linear no-threshold model. This model is generally recommended by the International Commission on Radiological Protection and the National Council of Radiation Protection and Measurements, and some radiation protection professionals believe this model produces a conservative estimate (that is, an overestimate) of health effects in the low-dose region, which is the exposure region associated with continued storage of spent nuclear fuel and high-level radioactive waste. This EIS summarizes estimates of the impacts associated with very small chronic population doses to enable comparison of alternatives in this EIS. Therefore, impact estimates should be viewed as conservatively high.

The Environmental Protection Agency has responsibility for setting applicable standards for Yucca Mountain. The Nuclear Regulatory Commission has responsibility for modifying technical standards for the repository to be consistent with the Environmental Protection Agency standards. The Environmental Protection Agency has established final regulations at 40 CFR Part 197. This regulation establishes individual protection and human intrusion standards requiring that DOE demonstrate that there is a reasonable expectation that for 10,000 years after disposal, the reasonably maximally exposed individual would receive no more than an annual committed effective dose of 15 millirem per year for Yucca Mountain. This level of exposure would, using the recommended risk factors discussed above (0.0005 latent cancer fatality per rem or 1,000 millirem), would represent a risk of contracting a fatal cancer of 8 chances in a million for one year of exposure or about 5 chances in 10,000 for a lifetime (70 years) of exposure. For comparison, based on the most recent statistics, individuals living in the United States have about a 1 in 4 chance of dying of cancer from all causes (DIRS 153066-Murphy 2000).

The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197 and represents an incremental lifetime risk of contracting a fatal cancer of less than 1 chance in 100 million (see Table 5-6). This level of risk is about 25 million times lower than the current risk of contracting a fatal cancer in the United States from all other causes.

7.5.7 (677)
Comment - EIS000205 / 0002
The DEIS does not note that waste repository release limits at Yucca Mountain would be much higher than the accepted standards set by the EPA [Environmental Protection Agency]. If the EPA had remained as the standard setter in this agreement, the Yucca Mountain site would indeed be disqualified. The plans for Yucca Mountain have been allowed to proceed only because Congress has agreed to more and more relaxed health and safety standards. We believe that the EPA should set the standards for radiation releases, and that groundwater at this site should be subjected to safe drinking water standards established by the EPA.

Response
The Energy Policy Act of 1992 requires the Environmental Protection Agency to set applicable standards for Yucca Mountain. The Act also requires the Nuclear Regulatory Commission to modify technical standards for the repository (10 CFR Part 63) to be consistent with the standards set by Environmental Protection Agency. DOE notes that the Environmental Protection Agency has established final regulations at 40 CFR Part 197. This regulation establishes individual protection and human intrusion standards requiring that DOE demonstrate that there is a reasonable expectation that for 10,000 years after disposal, the reasonably maximally exposed individual would receive no more than an annual committed effective does of 15 millirem per year for Yucca Mountain, and a groundwater protection standard of 4 millirem per year. The groundwater protection standards are consistent with the Environmental Protection Agency's safe drinking water regulations.

The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197.

With respect to groundwater protection standards set forth in 40 CFR 197.30, estimated groundwater concentration during the 10,000-year regulatory are thousands of times lower than the regulatory limits (see Table 5-13).

7.5.7 (678)
Comment - EIS000205 / 0003
We [Physicians for Social Responsibility (PSR)] also note the inconsistencies that appear when you compare health and safety standards for the Yucca Mountain site with those outlined for the Waste Isolation Pilot Project. The NRC [Nuclear Regulatory Commission] proposes radiation release rates of 25 millirem/year for Yucca Mountain as compared to a slightly better EPA [Environmental Protection Agency] standard of 15 millirem/year for WIPP [Waste Isolation Pilot Plant]. At WIPP, groundwater samples are to be taken 5 kms [kilometers] outside the site, while the Yucca Mountain measurements would be gathered from 20 kms away. The WIPP site currently has a groundwater standard of 4 millirems, while Yucca has none. PSR believes that Nevada residents deserve the same level of protection granted to residents of New Mexico and that everyone has the right to clean air and safe drinking water.

Response
As the commenter notes, the Environmental Protection Agency and the Nuclear Regulatory Commission are responsible for setting the radiation dose standards for two DOE repository facilities, the Waste Isolation Pilot Plant in Carlsbad, New Mexico, and the proposed repository at Yucca Mountain. Although compliance methods prescribed by their respective protection standards may be different, DOE believes both regulations provide essentially the same level of protection (to both individuals and groundwater) and that this level of protection is adequate to ensure that health impacts would be highly unlikely to occur.

The Energy Policy Act of 1992 requires the Environmental Protection Agency to set applicable standards for Yucca Mountain. The Act also requires the Nuclear Regulatory Commission to modify technical standards for the repository (10 CFR Part 63) to be consistent with the standards set by the Environmental Protection Agency. DOE notes that the Environmental Protection Agency has established new regulations at 40 CFR Part 197. This regulation establishes individual protection and human intrusion standards requiring that DOE demonstrate that there is a reasonable expectation that for 10,000 years after disposal, the reasonably maximally exposed individual receive no more than an annual committed effective does of 15 millirem per year for Yucca Mountain, and a groundwater protection standard of 4 millirem per year. The groundwater protection standards are consistent with the Environmental Protection Agency's safe drinking water regulations. The final Agency regulations specify that the point of compliance is at about 18 kilometers (11 miles). The Nuclear Regulatory Commission has issued final rules that are consistent with the Environmental Protection Agency rules (10 CFR Part 63).

The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197.

7.5.7 (688)
Comment - EIS000270 / 0015
Factors that give rise to public concerns about and opposition to approval of the Yucca Mountain site include:

Failure in dose calculations to account for the additive, multiplicative, and synergistic relationships of radiological and other biologically hazardous pollutants, factors, and conditions ultimately affecting recipients.

Response
The EIS presents the risks of exposure to ionizing radiation and hazardous chemicals separately, where the potential for these exposures could exist. A good scientific foundation for adding the risks of exposure to radiation and chemicals does not currently exist, even if target tissues were the same, because exposure pathways and cellular and molecular mechanisms of cancer induction could differ. The low levels of exposure to radiation and hazardous substances likely to occur from repository operations (Sections 4.1.2 and 4.1.7) and long-term performance (Sections 5.4 and 5.6) would be such that there would likely be no impacts, even though the linear, no-threshold application of risk factors generates fractional impact estimates, such as fractional latent cancer fatalities. Section F.1 of the EIS contains more information.

7.5.7 (838)
Comment - EIS000173 / 0004
Dairy cows graze fairly close to Yucca Mountain. Would you like your children to drink milk that may well have been contaminated with radioactive substances? Many people in this country have died from bone cancer caused by the milk they drank as children that contained strontium-90 from our atmospheric nuclear tests. Let's not make the same mistake of allowing radioactive isotopes in our milk again!

Response
The EIS evaluation of potential human health impacts of the Yucca Mountain Repository considered all exposure pathways, including the vegetation-to-cow-to-milk pathway. Sections G.2.4.1, I.2.9, and I.4.4.6 of the EIS include these pathways in the descriptions of dose factors for operations and long-term performance, respectively. The updated analysis presented in the Final EIS projects that the Proposed Action would likely result in extremely small

releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem, including milk pathways, which is more than 100,000 times less than the individual protection standard set by 40 CFR Part 197.

7.5.7 (846)
Comment - EIS000173 / 0012
Some of your studies have projected that there will be one extra cancer death per 1,000 in the population from the plan to transport spent fuel to Yucca Mountain. Some, however, have questioned your statistics which seem to average in radioactivity for the whole population of the United States and sometimes use the radiation level considered safe for adults without acknowledging that it is much lower for children and fetuses. However, even if we accept your estimate of one new death per 1,000 people, for the 50 million who live within half a mile of a transportation route, would this mean that 50,000 people would get cancer as a result of this plan? That is not acceptable to me. Who are these people who would die prematurely as a result of this plan? Many would be the Native Americans who live near Yucca Mountain and claim it as their own sacred property.

Response
DOE is unaware of studies that predict one death per 1,000 persons for transporting spent nuclear fuel to Yucca Mountain. The Department estimates three latent cancer fatalities could occur nationally as a consequence of transporting spent nuclear fuel using mostly legal-weight trucks and one latent cancer fatalities could occur from using mostly rail over the 24 years of the Proposed Action. These estimates are based on a large number of people each receiving a small radiation dose and assuming there is a risk of health effect without threshold (the linear no-threshold hypothesis). The dose and risk to individuals would be very small. For example, Section 6.2.3.1 of the EIS discusses that the maximally exposed resident along a legal-weight truck route would receive about six millirem over 24 years of transport, with a 0.000003 risk of latent cancer fatality (about 1 chance in 300,000). A small number of individuals (for example, a service station attendant where trucks stopped) could receive larger doses. Section J.1.3.2 describes the methods and assumptions DOE used to estimate such impacts.

DOE believes that adverse health impacts resulting from the Proposed Action are highly unlikely. For example, in the vicinity of the repository (the area within 50 miles), DOE estimates short-term impacts from construction, operation and monitoring, and closure of the proposed repository would result in less than 2 millirem per year to the maximally exposed member of the public (see Table 4-34 of the EIS). This exposure is less than 15 percent of the 15-millirem limit promulgated at 40 CFR 197.4 and 10 CFR 63.204 and less than 1 percent of the annual 200-millirem dose to members of the public in Amargosa Valley from background levels of naturally occurring radon-222 and its decay products. In addition, for the flexible design, for the first 10,000 years after repository closure, the mean peak annual receptor dose to the reasonably maximally exposed individual would be more than 100,000 times less than the individual protection standards at 40 CFR 197.20 and 10 CFR 63.311, which allow up to 15-millirem-per-year dose rates during the first 10,000 years (see Table 5-6).

The EIS also provides estimates of lifetime doses and additional fatal cancers for entire populations that could be affected by the Proposed Action. For example, DOE estimates that for the lower-temperature operating mode, the potentially affected population within 80 kilometers (50 miles) of the repository (estimated to be 76,000 individuals in 2035), could receive as much as 4,000 person rem over 341 years of operation that could result in as many as 2 additional cancer fatalities in the exposed population. This would represent an increase of 0.002 percent of the 89,000 cancer deaths expected to occur from natural causes in the potentially exposed populations over a 340-year period (that is, five 70-year generations). In all cases, these risks have been shown to be very low and, considering the conservatisms used in these estimates, likely nonexistent. As such, DOE believes that even if large-scale health studies were conducted, the identification of adverse health impacts resulting from the Proposed Action would not be discernible.

7.5.7 (848)
Comment - EIS002247 / 0005
I want to know if you took the Petkau effect into account when you figured out the health effects of this project. I know this is kind of a double-edged sword for you guys, because I know health effects in the DEIS means deaths, latent cancer fatalities; but as we all know, there are a lot other health effects from nuclear material, including birth defects, leukemia, childhood cancers, other cancers which are not necessarily fatal. And I want to whether or not the

Petkau effect which was discovered in 1972 by Canadian scientist Petkau, and basically says that low-level exposure -- constant low-level exposure has a much more detrimental effect on the human body than a single dose of this high level -- a single high-level dosage.

In fact, it's something like 5,000 times more -- it has more -- 5,000 times more effect on your body than if you are getting a constant low-level dose. That means the people in these corridors, the people here in San Bernardino County, will be getting these low-level doses, and I want to know if the Petkau effect was taken into consideration when dealing with the transportation, when dealing with the health effects. And I would like to hear more about that.

Response
The National Research Council (DIRS 153007-National Research Council 1980) evaluated the research of Dr. A. Petkau, which hypothesizes an alternative or conjoined damage mechanism for ionizing radiation in addition to effects on DNA. Effects on DNA are generally accepted as the primary modes of damage in biologic systems. Dr. Petkau suggested radiation damage to cellular and intracellular membranes is manifested by alterations in permeability, which lead to altered distribution of various intracellular molecules and ions and disruption of membrane-associated biochemical processes. Although it is well recognized that membrane integrity is essential for normal cell function, at the time of the BEIR III report there was inadequate basic understanding of membrane structure and function on which to base a detailed theory of radiation-induced damage mechanisms. Also, available data were not adequate to assess the role of radiation damage of membranes in the induction of pathologic states in living systems. Subsequent BEIR reports and National Council on Radiation and Protection and Measurement and International Commission on Radiological Protection recommendations have not considered non-nucleonic damage mechanisms (Petkau effects), presumably because of the lack of additional or supporting scientific research. Because DOE uses the recommendations of the Council and the Commission in making estimates of risk from exposure to ionizing radiation, Dr. Petkau's research was not considered.

7.5.7 (916)
Comment - EIS000089 / 0005
And then we're looking at the situation that they say twelve miles from there, which I just found out tonight is in this town. You're going to be getting one x-ray a year if you live at the twelve-mile parameter line they're coming up with.

That's what the EPA [Environmental Protection Agency] wants. The NRC [Nuclear Regulatory Commission] wants you to have a little bit more.

Well, how do they know that?

And then what happens at six miles into the animal life or what happens to animal life that spends a lot of time up there and then come out here? What happens a thousand years from now? They say in a million years.

They use all these big numbers that I don't understand. I'm only going to be getting 89 millirems a year at the twelve-mile line.

I want [to] know who thinks they could predict anything that's going to happen in a million years. These guys can't even tell us what's going to happen in ten years.

I do -- work for a lot of different companies because I'm one of those folks who come out here as a protester and found myself being here, so I do groundwater remediation work.

I worked at the Federal Building down there. I'm the guy that goes out and lays the hoses and the PVC pipe and making systems go that clean the groundwater under Las Vegas, and I see how they're supposed to have us trained to deal with this stuff, and when they dump it into the wash, that water is barely cleaner than when we pulled it out.

It's contaminated from the leaking gasoline tanks, from the diesel fuel, from the chemical plants, and all that stuff's happening in the last twenty years, and now you folks want us to believe that you can tell us what's going to happen 10,000 years from now?

Response
The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 100,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency (40 CFR Part 197).

In addition to the 10,000-year compliance period, DOE has evaluated potential impacts for the period of geologic stability at the repository (that is, 1 million years). This evaluation was performed in accordance with 40 CFR Part 197 to gain insight into the very long-term performance of the repository and thus provide information for the decisionmakers in making both design and licensing decisions. These results show a mean peak dose rate that is much lower than those resulting from natural background radiation (see Table 5-11 of the EIS for details).

With regard to differences between the Environmental Protection Agency and Nuclear Regulatory Commission protection standards, Section 801 of the Energy Policy Act of 1992 requires the Agency to set standards for the protection of public health and safety from releases from radioactive materials stored or disposed of at Yucca Mountain. The Agency issued a proposed rule (64 *FR* 46976) on August 27, 1999. The final rule, 40 CFR Part 197, was issued on June 13, 2001.

The Energy Policy Act of 1992 requires the Nuclear Regulatory Commission to publish final criteria for licensing consistent with the radiation protection standards set by the Environmental Protection Agency no more than 1 year after the Agency publishes its final rule. The Commission published a proposed rule (64 *FR* 8640, February 22, 1999) before the Agency published its proposed rule. As noted by this comment, the Commission rule was less stringent in some ways than that proposed by the Agency. However, in conformance with the Energy Policy Act of 1992, the Commission has issued a final rule (10 CFR Part 63) that establishes licensing criteria for the proposed geologic repository at Yucca Mountain, including a radiation protection standard, that are consistent with the radiation protection standards in the final Agency rule (40 CFR Part 197).

With regard to potential impacts of the Proposed Action on animal life, as discussed in Section 10.1.1.4 of the EIS, adverse impacts on regional populations of animals, including the desert tortoise, would be minimal and largely undetectable in part because the impacts would be restricted to a small area and the animal species found at Yucca Mountain are widespread throughout the region. Traffic and other site characterization activities during about 1991 to 1995 had no detectable effect on populations of desert tortoises and other animals monitored (DIRS 104593-CRWMS M&O 1999). Five desert tortoise deaths have been attributed to site characterization activities. The U.S. Fish and Wildlife Service issued a Biological Opinion (DIRS 104618-Buchanan 1997) that site characterization activities, which were similar in type and scope to the Proposed Action, would not jeopardize the continued existence of the Mojave population of the desert tortoise. The Final Biological Opinion for repository activities was issued in 2001 (see Appendix O of the EIS).

DOE acknowledges that it is not possible to predict with certainty what will occur hundreds or thousands of years in the future. However, DOE's confidence in the disposal techniques is based on defense-in-depth that, for example, placing drip shields over waste packages to account for uncertainties. DOE has adopted an assessment approach that explicitly considers the spatial and temporal variability and inherent uncertainties in geologic and biological components. The bases of the approach are summarized as follows:

1. The site description is based on extensive underground exploratory studies and investigations of the surface environment.

2. The reference design is based on laboratory investigations and conceptual engineering studies.

3. Features, events, and processes that could effect the long-term safety of the repository are identified.

4. Evaluation of a wide range of exposure scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical, and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as use of water supply wells, irrigation of

crops, and exploratory drilling; and low-probability events such as volcanoes, earthquakes, and nuclear criticality.

5. Development of alternative conceptual and numerical models to represent the features, events, and processes of a particular scenario and to simulate system performance for that scenario.

6. Parameter distributions to represent the possible change of the system over the long term and use of conservative assessments that lead to over estimation of impacts when there is insufficient information for use of a probability distribution.

7. Performance of sensitivity analyses.

8. Extensive peer review and oversight.

DOE believes this process results in a representative estimation of impacts and is sufficient for comparing the relative merits of the various repository scenarios.

DOE continues to evaluate the sufficiency of its approach of dealing with uncertainty at the process level (scientific) as well as the system level (modeling). A task force is reviewing and outlining further work to be completed on uncertainties before the time of License Application, should the repository be recommended and approved as a suitable site.

7.5.7 (926)
Comment - EIS000122 / 0001
The gentleman that spoke earlier up here at the table, I believe he said one rem 1,000 would kill people with cancer, might get in 1,000. I beg to differ with him.

One rem exposure, you will get cancer one person in 250. If ten rems of exposure, one in 25 would get lethal cancer.

Response
As explained in Section 3.1.8 of the EIS, National and international advisory organizations such as the National Council on Radiation Protection and Measurements and the International Commission on Radiological Protection have established estimates of the risk of latent cancer fatality from exposure to ionizing radiation. The Federal agencies responsible for dealing with exposures to radiation, including the Nuclear Regulatory Commission and DOE, have accepted the Council and Commission estimates and use them in their calculations of risk. For members of the general public the accepted dose-to-risk conversion factor is 1 latent cancer fatality per 2,000 rem of ionizing radiation received by an exposed population (0.0005 latent cancer fatality per rem). For workers the dose-to-risk conversion factor is 1 latent cancer fatality per 2,500 rem of ionizing radiation received by an exposed population. DOE used these factors in the EIS to estimate human health impacts from exposure to ionizing radiation.

7.5.7 (965)
Comment - EIS000268 / 0003
The DEIS fails to explicitly acknowledge the deadly nature of spent nuclear fuel (SNF) and high-level radioactive waste (HLW). Nevada's 1995 scoping comments recommended: "The radiological consequences of exposure and contamination and associated with each reference fuel type should be presented in terms understandable to the general public, and these consequences should be presented in the Executive Summary as well as in the body of the draft EIS." DOE has chosen to ignore Nevada's recommendation.

The DEIS barely discusses the radiological hazards of SNF. The Executive Summary states that spent nuclear fuel "consists mostly of uranium, and is usually intensely radioactive because it also contains a high level of radioactive nuclear fission products." [p. S-4] Volume 1 states that spent nuclear fuel "is intensely radioactive in comparison to nonirradiated fuel." [p. 1-6] Except for identifying cesium-137 as a major source of SNF preclosure impacts and shielding requirements. [p. A-9] Appendices A, F, and J provide little specific information on the hazards of SNF.

How dangerous is spent nuclear fuel? Specifically, how dangerous to human health is DOE's designated "typical fuel type," [p. A-14] a 26 year-old PWR spent fuel assembly with 39,560 MWd/MTHM burnup and 3.69 percent

U-235 initial enrichment? The DEIS fails to provide a technically accurate answer in language understandable to members of the affected public along the transportation corridors to Yucca Mountain.

Nevada's final comments will provide a detailed assessment of the full range of SNF and HLW irradiation and contamination consequences, expressed in the language of the health physics profession, complete with outputs from the ORIGEN2, RADTRAN, and RISKIND computer codes. Today we attempt to speak plainly, and conclude our preliminary analysis with the following observations.

The DEIS should have taken a conservative approach to radiological health effects by basing its evaluation on transportation 5 or 10 year-old SNF. DOE chose instead to evaluate 26 year-old SNF, which is considerably less dangerous. But even 26 year-old SNF is extremely dangerous. A person standing or sitting next to a single, unshielded 26 year-old SNF assembly for the amount of time that I have spoken this morning would receive a radiation exposure sufficient to cause death in 50 percent of the population. Extend the time to ten minutes, and death from classic radiation sickness replaces concern about latent cancer fatalities.

It works like this. Even after 26 years of cooling, the typical PWR assembly described in the DEIS contains 31,000 curies of cesium-137 and 21,000 curies of strontium-90, and is a powerful source of penetrating gamma and neutron radiation. Based on other DOE references, we estimate the surface dose rate to be at least 10,000 rem per hour, or about 166 rem per minute. A person standing or sitting next to an unshielded PWR assembly would receive at least 100 rem per minute.

How does the human body respond to such acute exposures? After one minute, mild symptoms of radiation sickness might appear, including vomiting and blood chemistry changes. After two minutes, vomiting and blood changes would definitely be expected, and cancer risk would approximately double. After six minutes, one could expect vomiting within three hours, followed by hair loss, and 50 percent probability of death within two months from hemorrhage or infection. After 10 minutes or more, vomiting would be expected within one hour, followed by severe blood changes, hemorrhage, infection, loss of hair, damage to bone marrow, and 80 to 90 percent probability of death within two months. The lucky few survivors would look forward to many months or even years of convalescence.

Response

DOE is well aware of the high external radiation fields associated with commercial spent nuclear fuel and the potential for very serious and deadly health effects from exposure to an unshielded fuel assembly. This is one reason the NWPA specifies isolation of this material in a deep geologic repository for thousands of years. However, with appropriate institutional controls an exposure to a member of the public or to nuclear facility workers due to an unshielded fuel assembly and high external radiation fields is not considered to be a credible scenario (an annual probability of less than 1 chance in 10 million).

DOE has reevaluated the fuel characteristics used for the base case accident analyses based on a hazard index approach as described in Section A.2.1.5. The revised fuel now used for the analyses in the Final EIS is younger than the fuel used in the Draft EIS. For example, the pressurized-water reactor fuel now used in the accident analyses ("representative" fuel) is 15 years old rather than 26 years old as assumed in the Draft EIS. DOE has also performed sensitivity analyses to determine the relationship between accident impacts and fuel characteristics. These studies indicate that the hottest fuel that could be received at the repository (5 years old) would produce impacts about three times higher than the representative fuel selected for the analysis. It should also be noted that accidents involving transportation casks and waste packages would not involve only the hottest fuel since licensing limitations preclude loading these containers with only the hottest fuel.

Appendix A of the EIS reports the expected radionuclide inventory in curies for contributing radionuclides for both "average" fuel used to estimate total repository inventory and "representative" fuel used for transportation and repository preclosure accident analysis. Tables A-9, A-10, A-12, and A-13 list these values on a per assembly basis, and Table A-11 lists the total projected number of curies by isotope for the Proposed Action and the additional inventory modules. The EIS analysis did not require surface dose rates for irradiated fuel, so Appendix A does not provide them. For transportation impacts, the EIS conservatively uses the U.S. Department of Transportation surface dose rate limit for all transportation casks when calculating incident-free risk impacts to the public. In addition, none of the severe accidents evaluated in a recent Nuclear Regulatory Commission report

(DIRS 152476-Sprung et al. 2000) would result in a release of spent nuclear fuel assemblies from their shipping casks or a direct exposure to the public. For repository operations, DOE estimated personnel exposures for various activities from shielded elements based on the representative fuel assemblies during normal operations and postulated accidents. In summary, the EIS analysis included all appropriate information required to assess impacts from the spent nuclear fuel and high-level radioactive waste.

7.5.7 (1132)
Comment - EIS000270 / 0016
Factors that give rise to public concerns about and opposition to approval of the Yucca Mountain site include:

Inadequate consideration of the traditional basis of risk acceptance: that, for any additional dose above naturally-occurring background radiation, the individual recipient shall obtain a benefit greater than or commensurate with the added risk incurred and shall have the option of refusing the additional dose.

Response
The Environmental Protection Agency has responsibility for setting applicable standards for Yucca Mountain. The Nuclear Regulatory Commission has responsibility for modifying technical standards for the repository to be consistent with the Environmental Protection Agency standards. The Environmental Protection Agency has established final regulations at 40 CFR Part 197. This regulation establishes individual protection and human intrusion standards requiring that DOE demonstrate that there is a reasonable expectation that for 10,000 years after disposal, the reasonably maximally exposed individual would receive no more than an annual committed effective dose of 15 millirem per year for Yucca Mountain. This level of exposure would, using the recommended risk factors discussed above (0.0005 latent cancer fatality per rem or 1,000 millirem), would represent a risk of contracting a fatal cancer of 8 chances in a million for 1 year of exposure or about 5 chances in 10,000 for a lifetime (70 years) of exposure. For comparison, based on the most recent statistics, individuals living in the United Stated have about a 1 in 4 chance of dying of cancer from all causes (DIRS 153066-Murphy 2000).

The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197 and represents an incremental lifetime risk of contracting a fatal cancer of less than one chance in 100 million (see Table 5-6). This incremental level of risk is about 25 million times lower than the current risk of contracting a fatal cancer in the United States from all other causes and far below that which people consider important to their everyday decisionmaking process (see Section F.1.1.5 for a discussion on risk perspectives). DOE believes that the benefits of safely isolating spent nuclear fuel and high-level radioactive waste from the accessible environment far out weigh the very small levels of additional risk associated with the long-term performance of the Proposed Repository.

7.5.7 (1133)
Comment - EIS000270 / 0018
Factors that give rise to public concerns about and opposition to approval of the Yucca Mountain site include:

Use of high costs to the generators of nuclear waste as a justification for relaxations of health and safety requirements.

Response
DOE has not proposed to amend its general guidelines (10 CFR Part 960) to mitigate the high costs to generators. Rather, the purpose of the new Yucca Mountain-specific guidelines (proposed 10 CFR Part 963) is to implement the NWPA, consistent with the current regulatory framework and technical basis for assessing the ability (or performance) of a geologic repository to isolate spent nuclear fuel and high-level radioactive waste from the environment.

Section 112(a) of the NWPA directs the Secretary of Energy (and by extension, DOE) to issue general guidelines for the recommendation of sites for characterization, in consultation with certain Federal agencies and interested

Governors, and with the concurrence of the Nuclear Regulatory Commission. These guidelines (issued in 1984 at 10 CFR Part 960) were to include factors related to the comparative advantages among candidate sites located in various geologic media, and other considerations such as the proximity to storage locations of spent nuclear fuel and high-level radioactive waste, and population density and distribution.

In 1987, amendments to the Nuclear Waste Policy Act specified Yucca Mountain as the only site DOE was to characterize. For this reason and given advancements in site characterization, DOE proposed in 1996 to clarify and focus its 10 CFR Part 960 guidelines to apply only to the Yucca Mountain site (proposed 10 CFR Part 963), but never issued these guidelines as final. In 1999, DOE proposed further revisions to the Part 963 guidelines for three primary reasons:

1. To address comments that criticized the omission of essential details of the criteria and methodology for evaluating the suitability of the Yucca Mountain site

2. To update the criteria and methodology for assessing site suitability based on the most current technical and scientific understanding of the performance of a potential repository at the Yucca Mountain site, as reflected in the DOE report, *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998)

3. To be consistent with the then-proposed site-specific licensing criteria for the Yucca Mountain site issued by the Nuclear Regulatory Commission (the Commission has since finalized these criteria at 10 CFR Part 63), and the then-proposed site-specific radiation protection standards issued by the Environmental Protection Agency (the EPA has since finalized these standards at 40 CFR Part 197)

In 2001, after the Agency's 40 CFR Part 197 and the Commissions 10 CFR Part 63 were finalized, DOE finalized its 10 CFR Part 963 guidelines.

DOE has modified Chapter 11 of the EIS to reflect the current status and content of the Department's site suitability guidelines.

7.5.7 (1139)
Comment - EIS000270 / 0026
To remedy DOE's misguided nuclear waste disposal policy, and to achieve the safest management and isolation of all radioactive materials and wastes, the Sierra Club strongly urges adoption of the Precautionary Principle by the Department of Energy.[1] This Principle is variously defined but in essence states: "Until a practice or substance is proven safe, it should be treated as though it is unsafe."

Unquestionably, ionizing radiation is not safe for living beings; the Linear Hypothesis of Dose and Response remains basic to radiation Standards. The Precautionary Principle helps us to avoid potentially dangerous impacts of substances that are persistent, toxic, and liable to bioaccumulate even when there is little scientific evidence to prove the strength of the causal link between release and effects.

The Precautionary Principle also implies that decision-makers should act in advance of scientific certainty to prevent harm to humans and the environment. In Canada, this principle has been expanded to cover all government policies with the potential to degrade the environment. The Bergen Declaration states, in part:

.....[P]olicies must be based on the Precautionary Principle. Environmental measures must anticipate, prevent and attack the causes of environmental degradation. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

This reasoning underscores the necessity of halting the accumulation of nuclear waste. It then follows:

- the task of the Department is to halt its relentless drive for approval of the inadequate Yucca Mountain site;

- explain to the Congress why it should not proceed;

- and give serious reconsideration to finding the least dangerous, most equitable methods of retaining control of all the radioactive wastes required to be disposed of in a regulated facility, in a manner that will best assure that future populations will have an opportunity equal with our own to be able to continue to maintain control for the duration of its hazardous lifetime.

[1] Wingspread Statement on the Precautionary Statement http://www.wajones.org/wajones/wingcons.html; Also see *Protecting Health & the Environment: Implementing the Precautionary Principle* edited by Carolyn Raffensperger and Joel Tickner, Island Press, 1999).

Response
DOE believes that precautionary measures should be taken especially where cause and effect relationships are not fully understood. For example, DOE uses the linear no-threshold hypothesis for estimating effects of exposure to low levels of ionizing radiation, where there is no definitive scientific evidence that ionizing radiation has an adverse effect. Note that exposure to natural background radiation is in the range of 300 millirem per year. The linear no-threshold hypothesis states the stochastic (that is, effects having a probability of occurrence rather than a threshold) cause and effect relationship of radiation noted at high doses and dose rates, namely cancer, are also presumed to occur at low doses and/or low dose rates. For purposes of radiation protection, national and international advisory groups, including the National Academy of Sciences, National Council on Radiation Protection and Measurements, and International Commission on Radiological Protection have recommended that it is both prudent and conservative to apply high dose or dose rate evidence to those situations where low doses or low dose rates may be received. DOE and other Federal agencies, including the Environmental Protection Agency and the Nuclear Regulatory Commission, have accepted the recommendations of these advisory groups for purposes of radiation protection and for making estimates of the risk from ionizing radiation exposure, adopting the linear, no-threshold hypothesis for estimating health effects from exposure to low levels of ionizing radiation.

With regard to this comment's suggestion that "...lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation," the National Academy of Sciences concluded that: "...[the] better safe than sorry... philosophy holds true only when unlimited resources are available to protect the public health and the environment. Once resources are acknowledged to be limited, overestimates of a particular risk are ultimately harmful to the public health because funds are diverted from larger risks to protect society from smaller risks. This diversion of funds ultimately will result in greater mortality than would have occurred if resources were spent in proportion to the amount of health benefit that would be achieved" (DIRS 154539-National Research Council 1995). The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the maximally exposed individual of less than 0.0001 millirem (see Table 5-6), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197 and represents an incremental lifetime risk of contracting a fatal cancer of less than one chance in 100,000,000 (see Table 5-6). This incremental level of risk is about 25 million times lower than the current risk of contracting a fatal cancer in the United States from all other causes and far below that which people consider important to their everyday decisionmaking process (see Section F.1.1.5 for a discussion on risk perspectives). DOE believes that the benefits of safely isolating spent nuclear fuel and high-level radioactive waste from the accessible environment far outweigh the small levels of additional risk associated with the long-term performance of the proposed repository.

With regard to the commenter's suggestion that DOE stop efforts to gain approval for a repository at Yucca Mountain, Congress specifically directed the Secretary of Energy to characterize and evaluate the Yucca Mountain site for suitability as a geologic repository. Through the NWPA, Congress established a process that will lead to a decision by the Secretary of Energy on whether to recommend to the President approval of the Yucca Mountain site for the development of a repository.

7.5.7 (1392)
Comment - EIS000418 / 0002
Considering that the half-life decay period of U-235 is 5,000 years, a 1 in 7,000 chance over 10,000 years would mean that those odds would hold BEFORE half of a given volume of Uranium would decay to lead. That presents a 1 in 7,000 risk of exposure at unsafe levels of radioactivity to the environment.

Response
The half-life of uranium-235 is about 700 million years (the half-life of uranium-238 is about 5 billion years). Over 10,000 years the probability that a given atom of uranium-235 will decay is about 1 in 100,000. DOE considered the contribution of the uranium isotopes (mainly uranium-234, -235, and -238) to the radiation doses that workers and members of the public could receive. In all cases, uranium isotopes (mainly because of their long half-lives and low radioactive decay rates) would be minor dose contributors in comparison to other radionuclides.

7.5.7 (1707)
Comment - EIS000640 / 0001
You know those animals that come from near Yucca Mountain, near the Nevada Test Site, those are animals we [Western Shoshone] eat. I mean, they might sound repugnant to you, but we eat squirrels and deer and gophers, and way back when we might have eaten snakes and whatever. But those are animals that do not know the boundaries of the little easement that you are going to put alongside the railroad. Those are animals that we're going to consume. And no one has put a study together to tell us about the long risk that we are going to have to take when we consume those animals. Those animals are part of our heritage. And no one has bothered to study what is happening to us because of our traditional foods.

Response
During the period of construction, operation and monitoring, and closure at the proposed Yucca Mountain Repository, the only radionuclides that expected to be released would be naturally occurring radon and radon decay products, and noble gases. Of these, only radon decay products have the potential to accumulate in the environment in the edible portions of animals that might live in the land withdrawal area. The consumption of meat accounts for about 5 percent of the dose from radon and radon decay products [using the dose screening factors described in Section G.2 of the EIS (see DIRS 101882-NCRP 1996)], assuming that the animals are at the same location as the person being exposed. If these animals roamed in the land withdrawal area closer to the repository, the concentration in meat could increase by as much as a factor of 5. The overall dose to a person living at the land withdrawal boundary could increase by about 20 percent. For the year of highest exposure this would represent an increase in dose from 1.3 millirem per year to about 1.6 millirem per year. No adverse radiation-related health impacts would be likely at these levels of exposure. DOE based this estimated increase on the consumption of 100 kilograms (220 pounds) of meat per year and the assumption that the radionuclide uptake in wild animals can be represented by domestic animal uptake.

In addition, the updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197. These dose estimates considered the food consumption habits of the potentially exposed population in Amargosa Valley including those of the Native Americans.

7.5.7 (2217)
Comment - EIS000621 / 0007
Will the radiation levels in our area be monitored?

Response
Routine monitoring of transportation routes would not likely be performed. A release of radioactive material would be unlikely to occur during transportation activities. In the unlikely event that contamination was discovered on the external surface of a shipping cask, DOE would evaluate the potential for spread of contamination and, if necessary, monitor and contain contamination along the transportation route as part of the response plan. In the unlikely event of an accident involving the transportation of spent nuclear fuel or high-level radioactive waste, the response plan would include environmental monitoring in the vicinity.

7.5.7 (2603)
Comment - EIS001257 / 0003
The risks to health and life are unacceptable due to the possible contamination of the groundwater and our environment. Your own evaluation states transportation of this material will result in approx. 18 latent deaths a year. Any number of deaths per year related to this disposal of nuclear waste is completely unacceptable.

Response
DOE recognizes that the risk of cancer and other health effects caused by exposure to ionizing radiation is of concern to many citizens. Thus, in addition to keeping radiation doses within Environmental Protection Agency's environmental protection standards (40 CFR Part 197) and Nuclear Regulatory Commission's licensing criteria (10 CFR Part 63), DOE is also committed to keeping radiation doses from Yucca Mountain-related preclosure activities to levels that are as low as is reasonably achievable. For example, in the vicinity of the repository (the area within 50 miles), DOE estimates short-term impacts from construction, operation and monitoring, and closure of the proposed repository would result in less than 2 millirem per year to the maximally exposed member of the public (see Table 4-34 of the EIS). This exposure is less than 15 percent of the 15-millirem limit promulgated at 10 CFR 197.4 and 10 CFR 63.204 and less than 1 percent of the annual 200-millirem dose to members of the public in Amargosa Valley from background levels of naturally occurring radon-222 and its decay products. For the flexible design, for the first 10,000 years after repository closure, the mean peak annual receptor dose to the reasonably maximally exposed individual would be more than 100,000 times less than the individual protection standards at 40 CFR 197.20 and 10 CFR 63.311, which allow up to 15-millirem-per-year dose rates during the first 10,000 years (see Table 5-6). The peaks would be even smaller at greater distances.

The EIS also provides estimates of lifetime doses and additional fatal cancers for entire populations that could be affected by the Proposed Action. For example, DOE estimates that for the lower-temperature operating mode, the potentially affected population within 80 kilometers (50 miles) of the repository (estimated to be 76,000 individuals in 2035), could receive as much as 4,000 person rem over 341 years of operation that could result in as many as 2 additional cancer fatalities in the exposed population. This would represent an increase of 0.002 percent of the 89,000 cancer deaths expected to occur from natural causes in the potentially exposed populations over a 340-year period (that is, five 70-year generations). This would represent an increase of 0.002 percent of the 89,000 cancer deaths expected to occur from natural causes in the exposed populations over a 340-year period. Similar estimates have been made for impacts to populations potentially exposed over 10,000 years (see Table 5-7).

With regard to health impacts associated with transportation, the analysis presented in the EIS estimates that 3 additional latent cancer fatalities could occur under the most hazardous transportation scenario (mostly truck).

Although low levels of radiation exposure are estimated to result from the proposed action to construct, operate and monitor, and close the proposed geologic repository and the EIS provides estimates of latent cancer fatalities that could result from these small doses, these estimates are provided primarily to inform the decisionmaking process by enabling a quantitative comparison of impacts between the alternatives evaluated in this EIS. In all cases, estimates of latent cancer fatalities resulting from very small doses summarized in the EIS should be viewed as conservatively high; in fact, the uncertainties and conservatisms associated with these estimates (see Sections K.4.3.2 and F.1.1.5) are such that DOE believes that any adverse health impacts resulting from these exposures would be highly unlikely or nonexistent.

7.5.7 (2653)
Comment - EIS000409 / 0010
The health effects as well as the stress is incalculable. What $ figure can be placed on the genetic changes, mental retardation etc. to our future generations? How many billions of dollars is spent on cancer treatments? We'd like to see estimated costs on the cancers that will occur. (numbers anticipated from YM project from all 43 state[s])

Response
DOE agrees that the potential public health impacts associated with the repository are important and thus has estimated a range of impacts to potentially exposed individuals and populations from both operational and accident scenarios. The health impacts caused by psychological stress rather than physical effects, however, are too attenuated to establish a clear causal relationship and cannot be calculated.

As pointed out in this comment, it is generally recognized that, in addition to fatal cancers, other health effects could result from exposure to radiation. Therefore, to enable comparisons with fatal cancer risk, the International Commission on Radiological Protection (DIRS 101836-ICRP 1991) suggested use of detriment weighting factor which take into consideration the curability rate of nonfatal cancers and the reduced quality of life associated with nonfatal cancer and heredity effect. However, as discussed in Section F.1.1.5, since both of these life-detriment factors, when taken together, are less than half of the fatal cancer risk, DOE has chosen to estimate total cancer fatalities as the major potential health effect from exposure to radiation.

With regard to estimating the cost of treating cancers that may result from activities discussed in the Final EIS, it should be pointed out that even under the most hazardous transportation scenario (mostly truck) the estimated incremental increase in cancer fatalities (about 3 deaths over the 24-year shipping campaign) represents an increase over the natural occurrence of cancer fatalities from all causes of less than 0.0002 percent in the exposed population of 7.2 million. In addition, as discussed in Section K.4, the large uncertainties associated with predicting adverse health impacts from very low dose cannot preclude the possibility that no additional cancer deaths may occur. Further, the cost associated with treating this small number of additional cancers would be very small in comparison to the health care cost for the 7.2 million potentially exposed individuals and therefore would not provide useful information for the decisionmakers.

7.5.7 (2867)
Comment - 010096 / 0024
Pages 3-4, 3-10, and 3-11 – The SDEIS indicates that S&ER Design fatalities from air quality, occupational health and safety and accidents will increase from a low of 1.82 to 3.8 deaths. It is not clear that the long-term performance benefits from a latent cancer fatality standpoint are greater than the increase in short-term deaths. In fact, Table 3-14 does not even address latent cancer fatalities. As a consequence, it is not possible within the SDEIS to conclude whether the S&ER flexible design is better from a fatality perspective. This is a critical shortcoming of the SDEIS.

Response
As noted on page 3-1 of the Supplement to the Draft EIS, the intent of presenting the "...primary impact indicators enables a comparison between the impacts of the flexible design and those [impacts] presented in the Draft EIS." The flexible design presented in the Supplement to the Draft EIS was carried forward to the Final EIS. The overall increase in the number of fatalities for the flexible design as noted in the comment is due mainly to the increase in the length of the project and the corresponding increase in the total number of workers needed to complete the project over the longer time period. The potential radiation dose or risk to any individual member of the public or of the workforce does not increase under the flexible design, shown in Section 4.1.7.5 of the Final EIS.

A similar comparison is made for long-term performance. Table 3-14 of the Supplement to the Draft EIS lists long-term performance impact indicators that show impacts from the flexible design to be lower than those of the Draft EIS thermal load scenarios. Individual doses are used in the Supplement to the Draft EIS to allow comparison between the thermal load scenarios of the Draft EIS and the flexible design. Table 3-14 shows the individual doses under the flexible design to be lower in every case. By extension, the number of potential latent cancer fatalities—although very low in every case—from the flexible design would also be lower than for the Draft EIS thermal load scenarios. Population impact estimates for long-term performance under the flexible design are provided in Chapter 5 of the Final EIS, similar to those shown in Chapter 5 of the Draft EIS.

DOE believes that information provided in the Final EIS on short-term and long-term health impacts and latent cancer fatality risks are sufficient for current decisionmaking.

7.5.7 (3038)
Comment - EIS000539 / 0003
The DEIS does not acknowledge the lethal nature of the waste and fails to provide sufficient information on the radiological characteristics of highly irradiated nuclear fuel. An adequate environmental review of the proposed repository program must absolutely address the deadly nature of the waste to be shipped and buried. Yet DOE barely touches on the radiological risks imposed by highly irradiated nuclear fuel.

Information on the total activity and curies and the surface dose rate in rems per hour of the assemblies of irradiated fuel is essential for the assessment of risk proposed by the transportation and burial of radioactive waste. Yet DOE does not provide such data.

For example, one unshielded assembly of the sort to be buried at Yucca Mountain would have enough radiation to give a person standing next to it a dose of at least 100 rem per minute, meaning that with 10 minutes' exposure, the person would almost certainly be doomed to death within two months. This would be a rather quick but certainly not painless death.

Response
DOE is well aware of the high external radiation fields associated with commercial spent nuclear fuel and the potential for very serious and potentially deadly health effects from exposure to an unshielded fuel assembly. This is one reason the NWPA specifies isolation of this material in a deep geologic repository for thousands of years. However, with appropriate institutional controls an exposure to a member of the public or to nuclear facility workers due to an unshielded fuel assembly and high external radiation fields is not considered to be a credible scenario (an annual probability of less than 1 chance in 10 million).

Appendix A of the EIS reports the expected radionuclide inventory in curies for contributing radionuclides for both "average" fuel used to estimate total repository inventory and "representative" fuel used for transportation and repository preclosure accident analysis. Tables A-9, A-10, A-12, and A-13 list these values on a per assembly basis, and Table A-11 lists the total projected number of curies by isotope for the Proposed Action and the additional inventory modules. The EIS analysis did not require surface dose rates for irradiated fuel, so Appendix A does not provide them. For transportation impacts, the EIS conservatively uses the U.S. Department of Transportation surface dose rate limit for all transportation casks when calculating incident-free risk impacts to the public. In addition, none of the severe accidents evaluated in a recent Nuclear Regulatory Commission report (DIRS 152476-Sprung et al. 2000) would result in a release of spent nuclear fuel assemblies from their shipping casks or a direct exposure to the public. For repository operations, DOE estimated personnel exposures for various activities from shielded elements based on the representative fuel assemblies during normal operations and postulated accidents. In summary, the EIS analysis included all appropriate information required to assess impacts from the spent nuclear fuel and high-level radioactive waste.

7.5.7 (3130)
Comment - EIS000726 / 0022
There is no mention of the impacts to the dairy at Amargosa Valley, nor of the impacts caused by or to the electronic battlefield that Fallon NAS operates along one of the transportation routes. I question the safety of nuclear waste shipments made through an electronic battlefield.

Response
Section 3.1.1.1 of the EIS acknowledges there is farming and dairy operations about 30 kilometers south of the proposed repository in the Amargosa Valley. DOE has assessed the potential health and safety issues, for all applicable environmental pathways for the repository, in Chapter 4 of the EIS.

With regard to the potential impacts caused by or to the electronic battlefield operated by the Fallon Naval Air Station, DOE does not consider the possibility of an aircraft crash, commercial or military, on a truck or train carrying spent nuclear fuel or high-level radioactive waste to be credible except at an intermodal transfer facility. Such an event (discussed in Section J.3.3.1) of the EIS would not result in a release of radioactive materials.

For a description of operations at the Naval Station Fallon, the reader is referred to the Final Impact Statement, Withdrawal of Lands for Range Safety and Training Purposes Naval Air Station Fallon, Nevada, Department of the Navy, May 1998.

7.5.7 (3312)
Comment - EIS001085 / 0002
The DEIS lacks some very basic radiological information of the site. For the purpose of future reference and comparison, the DEIS should be revised to include the following baseline background information:

1. The average and ranges of natural occurring radionuclide concentrations (U-238/Ra-226 [uranium-2381/ radium-226]) of the repository rocks.

2. The average and ranges of background external radiation levels inside and outside the ESF.

Response
Section 3.1.8 of the EIS has been revised to incorporate the requested information.

7.5.7 (3319)
Comment - EIS001000 / 0007
High-level radioactive waste contains tritium [radioactive hydrogen]. Radioactive and nonradioactive hydrogen is like Houdini. It can and does escape easily.

Scientists and health physicists and doctors have not yet learned everything they need to know about the hundreds of different man-made isotopes that are being created in nuclear power plants.

Response
Table A-11 of the EIS lists the estimated quantities of tritium in spent nuclear fuel at the time of emplacement. Those estimates indicate an overall tritium content of about 15 million curies. Releases of tritium during the period of repository operation would be limited to the number of commercial fuel rods with intact cladding that fails during this period which would be expected to be a very small number if not zero. As the commenter points out, other fuel types (for example, DOE spent nuclear fuel and a small amount of commercial spent nuclear fuel) would not be a source because of the tritium in these fuel type would have escaped at the time of cladding failure.

In addition, most of the tritium released during handling would remain in the water of the spent nuclear fuel handling basins (DIRS 104508-CRWMS M&O 1999).

For postclosure releases of radionuclides, DOE estimates that no radioactive material would reach the affected environment for many thousands of years. Since tritium has a 12.3-year half-life, its radioactivity would be reduced by about a million times every 250 years, so it would have decayed to insignificant levels before it could reach the accessible environment. Thus, it would not be a significant contributor to postclosure dose.

There is an extensive body of knowledge about the physiological effects of fission products and other radionuclides generated in spent nuclear fuel during reactor operations. DOE applied that knowledge to estimate health effects for a proposed repository at the Yucca Mountain site. The Department used the best available information and accepted methodologies to produce conservative best estimates (not underestimates) of health effects associated with a repository at Yucca Mountain.

7.5.7 (3596)
Comment - EIS000715 / 0006
It is vital that the DOE honestly characterize the potential impacts of groundwater contamination. The residents of the Amargosa Valley rely on the groundwater that runs beneath Yucca Mountain for drinking, washing, and irrigation. The cumulative effect of contaminated groundwater on these residents would be great. The DOE fails to adequately identify those who would be most severely affected by radiological contamination of groundwater. The DEIS identifies the “critical group reference person” as an adult who lives year round in Amargosa Valley, uses a well as a primary water source, and lives in a manner similar to a typical inhabitant of Amargosa Valley (p. 5-14). The DEIS should instead identify the maximally exposed individual (MEI) person as a fetus in the womb of a subsistence farmer in the Amargosa Valley region because this fetus would more accurately represent the individual whose health will be most at risk from groundwater contamination.

Response

Environmental Protection Agency rules (40 CFR Part 197) and Nuclear Regulatory Commission rules (10 CFR Part 63) specify protection of the individual as the standard of safety for the proposed Yucca Mountain Repository.

The Final EIS does not use the "critical group reference person." Rather, DOE uses the definition of the reasonably maximally exposed individual (RMEI) given at 40 CFR 197.21, which defines the individual as a hypothetical person who could meet the following criteria:

"(a) Has a diet and living style representative of the people who are now residing in the Town of Amargosa Valley, Nevada. DOE must use the most accurate projections, which might be based upon surveys of the people residing in the Town of Amargosa Valley, Nevada, to determine their current diets and living styles and use the mean values in the assessments conducted for Sections 197.20 and 197.25."

"(b) Drinks 2 liters (0.5 gallon) of water per day from wells drilled into the groundwater at the location where the RMEI lives. "

The location of the reasonably maximally exposed individual described in 40 CFR Part 197 would be where the predominant groundwater flow path crosses the southern boundary of the Nevada Test Site which coincides with the southern boundary of the controlled area as defined in the regulation. This point is approximately 18 kilometers (11 miles) from the proposed repository. DOE has concluded that it is not necessary to analyze in the Final EIS a hypothetical individual at locations closer than approximately 18 kilometers (11 miles) to the repository because it is unreasonable to assume that anyone would reside in this area, for these reasons:

- An individual would need to install and operate a water well in volcanic rock at more than 360 meters (1,200 feet) deep to reach the water table at costs significantly above (and likely prohibitive) those that would be incurred several kilometers farther south of the repository where the water tables lies less than 60 meters (200 feet) beneath the surface through sand and gravel

- Locations closer than about 18 kilometers (11 miles) are within the controlled area defined in the Environmental Protection Agency standard for a Yucca Mountain repository and therefore not in the postclosure accessible environment defined by the Agency.

The updated analysis in the Final EIS estimates potential groundwater impacts reported for the compliance point prescribed in 40 CFR Part 197 [about 18 kilometers (11 miles) from the proposed repository]. As part of a comprehensive presentation of impacts, this EIS is charged with providing groundwater impacts for two other important down gradient locations. These are 30 kilometers (18 miles), where most of the current population in the groundwater path is located, and 60 kilometers (37 miles) where the aquifer discharges to the surface (this location is known as Franklin Lake Playa). This analysis indicates that for the first 10,000 years there would be only very limited releases, attributable to a small number of early waste package failures (zero to three, and possibly as many as five) due to waste package manufacturing defects, with very small radiological consequences (see Table 5-6). For the first 10,000 years after repository closure, the mean peak annual receptor would be thousands of times less than the Environmental Protection Agency individual protection standard (40 CFR 197.20), which allows up to 15-millirem-per-year dose rates during the first 10,000 years. The peaks would be even smaller at greater distances.

A fundamental objective of radiation protection is the limitation of lifetime risk to an individual in the exposed population. As noted in Section F.1.1.5 of the EIS, cancer is the principal potential risk from exposure to low or chronic levels of radiation. The EIS provides estimates of latent cancer fatalities for the general population and for workers based on risk coefficients adopted by the National Council on Radiation Protection and Measurements (DIRS 101856-NCRP 1993). The risk coefficients depend on age. The risk factor for the general population is higher than that for workers due to the inclusion of children in the population group, while the worker group includes only people older than 18.

Section II.B of the preamble to the Environmental Protection Agency's regulations at 40 CFR Part 197 addresses health risks to sensitive subgroups of the potentially exposed population, including the embryo-fetus and children. The Agency notes that the fetus is more sensitive to radiation than adults and that the sensitivity is greatest from 8 to

15 weeks following conception. Article II.B provides the following lifetime risk factors for cancer and hereditary effects:

- 0.000575 per rem for fatal cancers for the general population
- 0.0003 per rem for fatal childhood cancers, from exposure in the fetal stage
- 0.0001 per rem for severe hereditary effects in offspring

The risk factors for childhood cancers and hereditary effects are smaller because the period of increased sensitivity is much shorter. Hence, at a constant exposure rate, fatal cancer in the general population remains the dominant factor.

There are a number of reasons why the embryo-fetus is not suitable as the hypothetical reasonably maximally exposed individual:

- The embryo-fetus is exposed for at most 9 months, compared to 70 years of exposure for an individual.

- The body of the mother protects the embryo-fetus. Many radionuclides are excreted or go first to the organs of the mother. Many particulate radionuclides do not cross the placental barrier.

- 40 CFR Part 197 and 10 CFR Part 63 do not include attributes of the embryo-fetus in the radiation protection rules.

- The database of scientific information on placental transfer of radionuclides and their concentrations and dosimetry in the human embryo-fetus is not extensive, and there are a number of unknowns and uncertainties about this information (DIRS 157140-NCRP 1998). As a basis for comparison, the National Council on Radiation Protection and Measurements recommends a dose limit of 50 millirem per month to protect the embryo-fetus of occupationally exposed women (DIRS 101856-NCRP 1993).

7.5.7 (4111)
<u>Comment</u> - EIS001476 / 0004
I also want to mention that it's not an isolated area. It's not desolate. Within a 20-mile radius there are about 50,000 people. If there was, like the DOE scientists themselves in 1995 reported that high-level radioactive waste in the repository could reach -- well, there goes all these people. And then what about the rest of the people downwind, and what about you and what about your children?

<u>Response</u>
Section 3.1.8 of the Draft EIS estimates the population within 80 kilometers (50 miles) of the repository to be about 28,000 people in the year 2000. Revised population estimates have increased this number, but only to about 34,000. The Final EIS was revised to project an estimated population of about 76,000 in the year 2035, the year considered to be representative of the total population over the time period representing repository construction, operation and monitoring, and closure. Sections 4.1.2, 4.1.7, 4.1.8, and 5.4 of the EIS consider the estimated health impacts of routine operations, accidents at the repository, and long-term repository performance, respectively.

The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197.

Very low probability accidents could have higher potential consequences than these very low radiation exposures, but DOE believes that adverse radiation-related health impacts would be highly unlikely in any situation.

7.5.7 (4149)
Comment - EIS001411 / 0001
As an undergraduate student pursuing a career in medicine, I feel that this document poses serious health risks to everyone involved. The Yucca Mountain Nuclear Waste facility should not be built when the DEIS blatantly ignores addressing the public safety threats this facility would impose if it were built.

The conclusion that the US Department of Energy (DOE) reached that supports the construction of the facility lacks substantial rationale. Surely it is preposterous to take the Draft Environmental Impact Statement (DEIS) seriously when it avoided confronting the public safety issues at hand.

As a concerned citizen of the United States of America, I see the construction of such a facility as a massive accident waiting to happen with profound health-related repercussions. I hope that you think not only about the problems that will be incurred a few years down the line, but take into account the threat a facility of this magnitude would impose on America a million years down the line.

Response
The EIS evaluated potential impacts to the environment and to the public resulting from normal operation and from accidents during construction, operation and monitoring, and closure of the proposed repository (see Chapter 4 and Appendixes F and H); from long-term (including 1 million years) repository performance (see Chapter 5 and Appendix I); from incident free transportation and from accidents during transportation of spent nuclear fuel and high-level radioactive waste (see Chapter 6 and Appendix J; from implementing the No-Action Alternative (see Chapter 7 and Appendix K); and considering the cumulative impacts of past, present, and reasonably foreseeable future actions (see Chapter 8).

The EIS evaluated potential exposures to naturally occurring radiological and nonradiological hazardous materials (for example, radon, cristobalite, and erionite) and toxic chemical (chromium) and radiological impacts associated with storage, transportation, handling, emplacement, and disposal of spent nuclear fuel and high-level radioactive waste. Quantitative estimates of these exposures and potential resultant impacts have been presented throughout Chapters 4, 5, 6, 7, and 8. For all cases evaluated in the EIS, the estimated impacts from the release of and exposure to toxic materials have been shown to likely be very small or nonexistent.

7.5.7 (4288)
Comment - EIS001160 / 0096
Page 4-45, Section 4.1.7, does not appear to consider exposure beyond 80 kilometers. The DEIS should indicate whether exposure beyond 80 kilometers is possible and if so, to what extent.

Response
The commenter is correct. The EIS does not consider exposures beyond 80 kilometers (50 miles). Exposures beyond that distance would be possible, but very small. Eighty kilometers is the established precedent for calculating the potential population (collective) dose around a nuclear facility. The National Council on Radiation Protection and Measurements report, *Principles and Application of Collective Dose in Radiation Protection* (DIRS 101858-NCRP 1995), contains a brief history of the development of the 80-kilometer application. The dose to the offsite maximally exposed individual at the southern boundary of the land withdrawal area [about 18 kilometers (11 miles) from the repository] would be no more than 2.5 millirem during the 5-year initial construction period. This dose would be about 3 percent of the 15-millirem-per year regulatory limit at 40 CFR 197.4 and 10 CFR 63.204. At 80 kilometers (50 miles) from the repository, the potential for exposure would be even less.

7.5.7 (4603)
Comment - EIS001202 / 0003
The DEIS expected annual dose to an average individual living 20 km from repository shall not exceed 25 mrem [millirem] from all pathways is still in excess of the 15 mrem that the EPA [Environmental Protection Agency] says is safe. The idea that 25 mrem is expected is totally unacceptable.

Response
At the time the Draft EIS was issued, neither the Environmental Protection Agency (EPA) nor the Nuclear Regulatory Commission (NRC) had finalized their respective Yucca Mountain regulations. At that time, the EPA

was proposing an individual protection standard of 15 millirem per year while the Commission was proposing 25 millirem. However, the Energy Policy Act of 1992 requires the NRC to publish final criteria for licensing consistent with the radiation protection standards set by EPA no more than 1 year after EPA publishes its final rule. The NRC published a proposed rule (64 *FR* 8640, February 22, 1999) before EPA published its proposed rule. As noted by this comment, the NRC rule was less stringent in some ways than that proposed by EPA. However, in conformance with the Energy Policy Act of 1992, the NRC has issued a final rule at 10 CFR Part 63 that establishes licensing criteria for the proposed geologic repository at Yucca Mountain, including a radiation protection standard, that is consistent with the radiation protection standards in the final EPA rule.

The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by EPA at 40 CFR Part 197.

7.5.7 (4627)
Comment - EIS001433 / 0009
The predicted long-term health consequences of the construction, operation, monitoring and closure of the geological repository are arguably incorrect about yearly predicted cancer fatalities because the figures are based upon data for male subjects, and the more sensitive parts of the population, such as children and pregnant women, are not taken into account. (DEIS F.2.1)

Response
The radiation risk factor for the whole population, which is 1 latent cancer fatality per 2,000 rem of ionizing radiation received by an exposed population (5×10^{-4} per rem), includes all segments of the population, including the more sensitive individuals noted in the comment. Children, who are more sensitive than adults to the effects of radiation (cancer induction), comprise a relatively large part of the population. As a consequence, children are the principal reason the risk factor for the whole population is 25 percent higher than the factor for workers. Although the embryo-fetus is more radiosensitive (with a radiation risk factor about twice that for the whole population), it is protected by the body of the mother and comprises a small part of the whole population. The National Council on Radiation Protection and Measurements recommends a dose limit of 50 millirem per month to protect the embryo-fetus (see DIRS 101856-NCRP 1993). Other types of individuals (pregnant women, the aged, and those with impaired health) are not unduly radiosensitive, especially to low levels of radiation. Impacts to human health from exposure to radiation are discussed in Section F.1.1.5 of the EIS.

7.5.7 (4876)
Comment - EIS000337 / 0016
Pg. 3-79, Section 3.1.8, Occupational and Public Health and Safety: This section is a play on numbers. Public health officials are always trading off for example, the amount of people who will die from a flu shot vs. how many will die if there is no flu shot available. All these calculations are irrelevant if there was a method to keep the flu out of the state. I don't believe it is the number who will die that is important but the number whose quality of life will be diminished because of the proposed project. This is very difficult, if not impossible, to quantify especially when children and pregnant women are factored into the equation. I saw no data on how the radiation exposure is increased by the concentration of the radiation when cows digest grass that is radiated, drink water and then the milk sold to citizens. Root plants also will concentrate the radiation. I did not find any mention of this in the report.

Response
The purpose of Chapter 3 of the EIS is to describe the affected environment in the vicinity of Yucca Mountain to establish a baseline against which the analyses described in later chapters can measure potential environmental impacts. It does not present analyses of potential impacts from Yucca Mountain activities. Sections 4.1.2, 4.1.7, 5.4, 8.2.2 and 8.2.7 of the EIS describe these analyses.

Radiation-related health effects and a decrease in quality of life would be unlikely from radiation exposures resulting from the Proposed Action. Latent cancer fatality is the principal risk from exposure to ionizing radiation. DOE recognizes the potential for other types of health effects, namely nonfatal cancer and hereditary disorders. Section F.1.1.5 of the EIS discusses the potential for other effects.

Radiation risk factors include potential impacts to children and pregnant women. Pregnant women are no more sensitive to ionizing radiation than other adults. Although the embryo-fetus is more radiosensitive, the body of the mother protects it, so environmental radiation exposures are usually of little concern. The analyses considered the exposure pathways noted by the commenter—vegetation to grass to milk and uptake by plants. The EIS discusses these pathways in Section G.2.4 for repository operations and Section I.4.5.6 for long-term performance assessment.

7.5.7 (4877)
<u>Comment</u> - EIS000337 / 0017
Pg. 2-84 [3-84], Section 3.1.8.3: The discussion focuses on the workers in the tunnel. There is no mention of the workers who are not in the tunnel but will be exposed to the dust from the material removed from the drilling. What is the impact of strong winds moving the material to the public? DOE's position is that they will "use the experience gained during Experimental Studies Facility activities to design engineering controls to minimize future exposures." What does the statement mean? How many will have a reduced quality of life and how many will die? Are these people working for a company who come under SISS?

<u>Response</u>
Chapter 3 of the EIS describes the affected environment in the vicinity of Yucca Mountain to establish a baseline against which DOE can measure potential environmental impacts. The excerpt referred to by the commenter specifically refers to the use of engineering controls to reduce future exposures to dust. These controls are preferable to the use of personal respirators and could include such dust suppression methods as water sprays and ventilation filtration.

Sections 4.1.2 and 4.1.7 describe the potential impacts discussed in this comment. DOE would use engineering and practical experience gained during excavations in the Exploratory Studies Facility to ensure that exposures to workers to during repository operations would be within regulatory limits and as low as reasonably achievable. Sections 4.1.2 and G.1 evaluate surface exposures from excavated material to workers and the public. Overall, worker and public exposure to excavated material would be small fractions of regulatory limits. No deaths or reduction in quality of life would be expected among workers or members of the public from these exposures.

7.5.7 (4967)
<u>Comment</u> - EIS001326 / 0001
My question for you is how can you be sure that we won't all be exposed to radiation and the young engineers in fifty years will have cancer?

I have learned that you will never be positive on the amount of radiation that we might be exposed to. Before even beginning to create such large amounts of nuclear power and storage of radiation you first must be sure that there is no glitches.

<u>Response</u>
Potential health impacts to the workers identified in the comment have been examined in the EIS, except the impacts to workers at the nuclear powerplants. These actions have been evaluated in separate National Environmental Policy Act documents prepared by the Nuclear Regulatory Commission as part of the licensing process for nuclear powerplants. The EIS considered the potential impacts to nuclear plant workers who would load the casks onto trucks or trains for transportation to Yucca Mountain, activities which are related to the repository and therefore within the scope of the EIS. However, occupational radiation exposure at Commission-licensed facilities is monitored and reported in strict accordance with regulations codified at 10 CFR Part 20.

Potential impacts to workers at the repository are discussed in Section 4.1.7 of the EIS while impacts to workers involved in the various aspects of transporting commercial spent nuclear fuel are discussed throughout the health and safety sections in Chapter 6. Workers at Yucca Mountain may be exposed during the period of construction, operation and monitoring, and closure, which could total up to more than 300 years. For purposes of analysis, individual workers were assumed to be occupationally exposed for up to 50 years. Transportation activities for the proposed action were estimated to last 24 years.

The main source of radiation exposure to workers is the penetrating electromagnetic external radiation (gamma rays), not radioactive emissions or contamination from the spent nuclear fuel assemblies. The potential for exposure to radioactive emissions or contamination is very low at Yucca Mountain. If the repository was approved for development, the approval of a license to operate would require strict compliance with occupational radiation protection standards similar to those at 10 CFR Part 20, thus ensuring the health and safety of the radiation workers at the repository.

7.5.7 (5617)
Comment - EIS001887 / 0244
Page 4-58; Table 4-32 - Estimated impacts to workers from industrial hazards for all phases

The statistics shown in this table are based on a DOE worker data base that is not consistent with national labor statistics. The national labor statistics data base should be used because repository construction and operation will best resemble an industrial work environment with an emphasis on daily work production and efficiency, rather than a DOE work environment where meeting production goals is not so closely linked to a profit motive. This approach would be consistent with the analysis approach used in Section 4.1.15, Impacts From Manufacturing Disposal Containers and Shipping Casks.

Response
Table 4-25 of the Final EIS lists values for impacts from industrial hazards for preclosure operations at the proposed repository. DOE used industrial hazard statistics developed from its experience in similar kinds of operations to calculate these values. Tables F-2 and F-3 list the values. Section F.2.2.2 explains that industrial loss statistics were based on DOE rather than industrial experience since there have been no reported fatalities as a result of workplace activities for the Yucca Mountain Site Characterization Project nor are there fatalities listed in the Mine Safety and Health Administration data base for stone mining workers. Because fatalities in industrial operations sometimes occur, the more extensive overall DOE database was used to estimate a fatality rate for the activities at the Yucca Mountain site. DOE would perform preclosure activities at Yucca Mountain under DOE Orders and Directives rather than the approaches followed in industrial construction and mining operations. The loss statistics listed in Table F-3 for site characterization activities at the Yucca Mountain site, which were performed under DOE Orders and Directives, generally agree with the values in Table F-2, which are used to make industrial safety impact estimates.

With respect to operations involved in manufacturing disposal canisters cited by the commenter, DOE would contract the fabrication of canisters to a commercial manufacturer, which would not use the DOE Order system. Therefore, Section 4.1.1.5 of the EIS presents a different set of statistics (based on industrial experience) for the industrial safety impact estimates for the manufacture of shipping casks.

7.5.7 (5618)
Comment - EIS001887 / 0243
Pages 4-44 through 4-60; Section 4.1.7 - Occupational and Public Health and Safety Impacts

Based on the Draft EIS, health impacts to workers and the public from initial construction through continuing construction, operation and monitoring, and eventual closure of the repository are expected to be relatively non-existent. A critical review of this apparent lack of danger to workers and the public reveals a disregard for analytical consistency on the part of the Department of Energy, the application of different measurement standards for workers and the public, and the use of a large number of unverifiable assumptions. The resulting analysis is confusing, at best, to both technicians and the public and provides virtually no basis for a scientifically valid decision making process. For example:

Section 4.1.7.5.1 indicates that only 1.5 to 2.0 worker fatalities related to industrial hazards will occur during the entire 110-120 years of construction, operation, and closure. This is inconsistent with other information in the Draft EIS.

Section 4.1.7.5.2 states that, based on a 50-year work life, impacts to workers in all phases of the repository activities will result in only 2.5-4.0 Latent Cancer Fatalities over 110-120 years. The highest collective dose is estimated to occur in relation to the uncanistered, low thermal load scenario and is calculated at 10,700 person-rem over the 110-120 years of operation. (NOTE: Section 7.1.7, “Short-Term Impacts in the Yucca Mountain Vicinity” indicates a collective dose to workers of 77 person-rem, which is inconsistent with Table 4-33 referenced in this section.)

Section 4.1.7.5.3 summarizes public health impacts in all phases of repository development as resulting in only 0.14-0.41 Latent Cancer Fatalities and indicates that "additional LCFs from short-term activities" will equal less than 0.4 or an increase of 0.01% over the existing average occurrence. Over the full range of construction and operation of the repository, the highest annual dose to the public is identified as 1.5 mrem "or less."

Section 4.1.8.1 informs the reader that, in the event of a catastrophic earthquake, the worst case population exposure would cause only 0.0072 Latent Cancer Fatalities. A summary of exposure statistics for all potential environmental accidents shows that less than 0.02 additional LCFs would occur in the general population.

Section 4.1.15.5.2 illustrates that there will be absolutely no deterioration of worker safety or resulting increase in accidents during the manufacture of disposal containers and shipping casks because there would be no unusual demands on existing facilities.

Section 4.2.1.2.7 states that no health and safety impacts (other than industrial hazards) will occur during the construction sub-period related to retrieval. However, during the 11-year operations sub-period, while industrial hazards will remain about the same for all thermal load scenarios and the LCF for the Maximum Exposed Worker with a total exposure of 6950 millirem will be 0.015, the "calculated LCF" for all workers during retrieval is given as 0.19. During this same period, the Maximum Exposed Individual (MEI) in the public will receive 5.5 mrems, and the LCF is estimated to be 2.8×10^{6}. The "total population" collective dose is listed as 28 "person-rems," with LCFs equaling 0.014. "Exposure to the public for operations only" is noted as 0.1 Latent Cancer Fatalities. Surface and subsurface workers end up with a low 0.003 LCF probability and 0.19 LCFs during the retrieval period.

Section 8.2.7 informs the reviewer that the cumulative impacts of the Nevada Test Site activities and historic dose scenario, combined with whatever impacts will or will not occur as a result of Yucca Mountain activities, will result in "less than 1 additional LCF." Whether this number was calculated in addition to already identified LCFs related to Yucca Mountain and indicates only the increase occurring from NTS is unclear.

Reciting dose numbers and LCF estimates only serve to reinforce the fact that, based on information provided by DOE, it is virtually impossible to determine whether there will, or could be, any measurable worker or public health and safety impacts as a result of the proposed construction and operation of a Yucca Mountain repository. Based on these inadequacies, the State specifically requests a re-draft of the Occupational and Public Health and Safety analysis contained in the Draft EIS.

Existing sections on health and public safety are written in confusing jargon and conflicting technical terminology and do not provide opportunity for the public or decision makers to distinguish between routine radiological risk and radiological exposure risk related to the Proposed Action. The Draft EIS suffers from extensive shortcomings in analytical and statistical methods and serves to overstate DOE's ability to analyze potential radiation effects related to the Proposed Action.

Response

DOE believes that the analysis is internally consistent. Responses to specific comments are presented below.

As discussed in Section 4.1.7.5.1 of the Draft EIS, industrial hazards are those common to any industrial setting. They do not include potential fatalities from radiological or nonradiological, or hazardous substance exposure. The value of 1.5 to 2 is consistent throughout the Draft EIS.

The estimate of 2.5 to 4 radiation-related latent cancer fatalities presented in Section 4.1.7.5.2 is correct and consistent throughout the Draft EIS. The estimate presented in Section 7.1.7, is part of the No-Action Alternative, where repository activities would be completely different than those discussed in Chapter 4.

The estimate of 0.14 to 0.41 latent cancer fatalities in Section 4.1.7.5.3 of the Draft EIS is for the entire project duration. The characterization of "less than 0.4" is a one significant figure reference to this range of impacts. This value, compared to the normal Nevada cancer incidence noted (more than 5,000 over the life of the project), would result in the stated increase of less than 0.01 percent. This section of the EIS has been clarified per the reviewer's comment.

The commenter refers to information in Section 4.1.8.1 on page 4-64 of the Draft EIS. The Draft EIS notes that a "summation [not 'summary'] of all potential accidents in Table 4-36 would result in less than 0.02 additional latent cancer fatality for the exposed population." That is, if all the postulated accidents occurred, only an additional 0.02 latent cancer fatality would occur.

Normal industrial accidents and no fatalities would be expected, as presented in Section 4.1.15.5.2.

In Table 4-56 of the Draft EIS, the probability of a latent cancer fatality for the maximally exposed subsurface facility worker from hypothetical retrieval operations, an individual who receives a dose of 6,950 millirem would be 0.003. A value of 0.015, as noted in this comment, is in error. The latent cancer fatality incidence, that is, the number of latent cancer fatalities, in the total exposed population of surface and subsurface workers, would be 0.19. For the maximally exposed member of the public, the probability of a latent cancer fatality in this individual is $2.8 \times 10\text{-}6$. The number of latent cancer fatalities that could occur in the exposed public population is 0.014.

The entire paragraph in 4.2.1.2.7 of the Draft EIS where the value of 0.1 latent cancer fatality for "exposure to the public for operations only" is a typographical error and incorrectly duplicates the information in the previous paragraph. This paragraph has been deleted from the EIS.

The total potential radiological impacts to workers and the public from the three thermal load scenarios of the Proposed Action are clearly noted in Section 4.1.7.5 of the Draft EIS. They are the same values discussed earlier in this comment, namely 2.5 to 4.0 Latent cancer fatalities for workers and 0.14 to 0.41 latent cancer fatality for the public. More detailed breakout of information is presented in other sections of Chapter 4. These same values are also presented in the Tables S-1 and 2-7. The retrieval period is not considered part of the Proposed Action, and so potential impacts are presented separately.

Section 8.2.7 of the EIS presents a discussion of the cumulative impacts to the environment if the decision were made to construct a repository at the Yucca Mountain site. In the introduction to Chapter 8 of the EIS, a cumulative impact as defined by the National Environmental Policy Act is "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions" (40 CFR 1508.7). Therefore, consistent with the National Environmental Policy Act, the impacts would be in addition to those latent cancer fatalities calculated for Yucca Mountain activities.

In response to public comments, DOE has revised the Draft EIS to provide additional clarification on potential health and safety impacts. In particular, Section F.1.1 now includes explanations of the impact parameters used, namely the probability of latent cancer fatality in an exposed individual and the number of latent cancer fatalities in an exposed population. The potential for nonfatal radiation effects is also included.

7.5.7 (5639)
Comment - EIS001887 / 0262
Page 4-107; Section 4.2.1.2.7 - Table 4-56: Radiological health impacts from retrieval operations

The uncertainty in these calculated doses and risks should be provided. The operational procedures are conceptual, at best; therefore, the uncertainties associated with various operations scenarios should be provided as part of this evaluation.

Response
Table 4-56 of the EIS lists the estimates of radiological consequences (dose) and health impacts (latent cancer fatalities) for retrieval operations. The dose values are based on the best available data as is required under National Environmental Policy Act guidance issued by the Council on Environmental Quality. DOE recognizes that there are uncertainties in both the full time equivalent worker year estimates; and in the estimates of the worker doses that would be received from inhalation of radon from background radiation from the drift walls and from radiation

emanating from the waste packages during work in the subsurface environment. However, these data are not available upon which to base meaningful uncertainty estimates.

With regard to radiation exposure and the incidence of cancer, as discussed in Sections K.4.3.2 and F.1.1.5, the dose-to-risk conversion factors typically used to estimate adverse human health impacts resulting from radiation exposures contain considerable uncertainty. The risk conversion factor of 0.0005 latent cancer fatality per person-rem (or, one latent cancer per 2,000 rem of exposure) of collective dose for the general public typically used in DOE National Environmental Policy Act documents is based on recommendations of the International Commission on Radiological Protection (DIRS 101836-ICRP 1991) and the National Council on Radiation Protection and Measurements (DIRS 101857-NCRP 1993). The factor is based on health effects observed in the high dose and high dose rate region (20 to 50 rem per year). Because health effects in humans have not been observed below acute 10-rem exposures, potential health effects were extrapolated to the low-dose region (less than 10 rem per year) using the linear no-threshold model. This model is generally recommended by the International Commission on Radiological Protection and the National Council of Radiation Protection and Measurements, and some radiation protection professionals believe this model produces a conservative estimate (that is, an overestimate) of health effects in the low-dose region, which is the exposure region associated with continued storage of spent nuclear fuel and high-level radioactive waste. This EIS summarizes estimates of the impacts associated with very small chronic population doses to enable comparison of alternatives in this EIS. Detailed discussions of other uncertainties associated with impact estimated are provided in Sections K.4.3.2 and F.1.1.5 of the EIS.

7.5.7 (6071)
Comment - EIS001898 / 0018
Inconsistencies concerning the appropriate range for 222Rn concentration should be remedied and impacts of thermal loading on radon release and worker safety should be explained in the FEIS.

Basis:

The median and range of 222Rn concentrations used for radiological impact calculations are not consistent throughout the DEIS. Sections 3.1.8.2 (Affected Environment-Radiation Environment in the Yucca Mountain region) and F.1.1.6 (Human Health Impacts Primer and Details for Estimating Health Impacts to Workers from Yucca Mountain Repository Operations-Exposures from Naturally Occurring Radionuclides in the Subsurface Environment) of the DEIS report that radon concentrations in the Exploratory Studies Facility (ESF) during working hours (with active ventilation) range from 0.22 to 72 pCi/L, with a median concentration of 6.5 pCi/L. Sections 4.1.2.2.2 (Environmental Consequences of Repository Construction, Operation and Monitoring, and Closure-Radiological Impacts to Air quality from Construction) and G.2.3.1 (Air Quality-Release of Radon-222 and Radon Decay Products from the Subsurface Facility) of the DEIS report that radon concentrations in the ESF during working hours with the ventilation system on range from 0.65 to 163 pCi/L, with a median concentration of 24 pCi/L. The difference is a factor of 2-3 in the range and a factor of approximately 4 for the median.

Section 4.1.7.3.1 [Environmental Consequences of Repository Construction, Operation and Monitoring, and Closure-Occupational Impacts (Involved and Non-involved Workers)] of the DEIS states that "radiological health impacts to surface workers would be independent of the thermal load scenarios." However, it is not apparent whether there was any consideration of higher heat loadings increasing the radon release rate from the wall surfaces. Table G-48 of the DEIS reports that the annual average radon releases during the 24-yr operation period are expected to be 880 Ci, 1000 Ci, and 1900 Ci for the high, intermediate, and low thermal loads. It also appears that these source terms did not take into account the relative volume of the repository under each heat loading alternative.

Recommendation:

The FEIS should explain or address inconsistencies related to the appropriate range for 222Rn concentration. The FEIS should also discuss the effects of the various heat loading scenarios on total radon release and provide a technical basis for the conclusion that radiological health impacts are independent of thermal load scenarios.

Response

These sections differed because some addressed exposure of workers during working hours, while others addressed the continuous exposure of members of the public. Sections 3.1.8.2 and F.1.1.6 are specifically concerned with the potential exposure of workers. Radon concentrations at points of exposure within the repository and several kilometers from repository ventilation exhaust are considerably different. The use in the Draft EIS was consistent and appropriate.

The Final EIS uses more recent repository radon flux information that has become available since the Draft EIS was published. This new information has replaced much of the information used as the basis of estimates in the Draft EIS. Dose estimates to subsurface workers from radon decay products now use Working Level estimates made for the flexible design (DIRS 154176-CRWMS M&O 2000). Section F.1.1.6 of the Final EIS describes these dose estimates. Working Level estimates can be converted to estimates of dose using a published conversion factor (DIRS 103279-ICRP 1994). Dose estimates for members of the public are also based on new estimates of radon release from the repository, which take advantage of new analyses of ventilation and radon flux from the repository walls (DIRS 150246-CRWMS M&O 2000; DIRS 154176-CRWMS M&O 2000). Section 4.1.2 reports revised dose estimates for the public from radon.

Information was not available for the Draft EIS to take into account the effect of heating of the emplacement drift walls by the waste packages. The analyses noted above have addressed the effect of heating (DIRS 154176-CRWMS M&O 2000), and the Final EIS takes this factor into account. All analysis scenarios for the Draft and Final EIS account for the effects of different repository sizes or volumes. A larger repository has a correspondingly larger radon release. However, the radon flux from repository walls and total radon release is not directly proportional to the total repository volume. Radon flux and release depend on the specific characteristics of the repository, including the relative quantity of larger-diameter excavations such as access mains, 5.5-meter (18-foot)-diameter excavations such as emplacement drifts, and smaller excavations such as ventilation raises. Radon release also depends upon the project phase, and whether or not a specific excavation would have a concrete liner (which would reduce radon flux).

The statement in Section 4.1.7.3.1 of the Draft EIS that radiological health impacts in the "surface" facilities are independent of thermal load scenarios is unrelated to subsurface radon release. The bulk of dose to surface workers is due to handling of spent nuclear fuel, which depends on the facility throughput, (that is, 63,000 metric tons of heavy metal for the Proposed Action). The dose contribution from radon released from the subsurface is negligible. These statements remain correct for the Flexible Design evaluated in the Final EIS. Additional clarification on the contribution of subsurface radon to workers doses has been added.

Sections G.2 and F.1.1.6 have been extensively revised in the Final EIS to present the new information noted above, as have the corresponding impacts in Sections 4.1.2 and 4.1.7.

7.5.7 (6082)

Comment - EIS001469 / 0005

We would think that it would be important for public process that the document be made as easy to read and as clear to find information as possible, and this doesn't seem to really be the case.

I want to give an example. Page 277 [2-77] of Volume 1 gives a table. This same table is duplicated in the summary document as well. And so this table is, in my opinion, an important part of what people will look at first in looking at the document. I want to point out something, some inconsistencies here.

First of all, there's a section in the table which indicates accidents. Doesn't say transportation, but it seems like that's the intent here. And there's categories under accidents. I'm going to focus on the category called Public, and there is Public Radiological, and bracketed it says LCF, which is latent cancer fatalities. So that should mean the number of fatalities in my reading of this document.

Under that category there are two sections, one called MEI, which is the maximally exposed individual, and the other is called Population. Okay. So if we go to the proposed action and we look under transportation, transportation column, I notice that the LCF number is lower for the maximally exposed individual than it is to the general population on the average. There's a range there, but the average number would definitely be lower. This doesn't really make any sense to me. I don't understand why the maximally exposed individual would be less likely to receive cancer than the general population.

Further, I attempted to find out why this might be the case in the document, and I noticed something else rather interesting. Under the maximally exposed individual, if you go back on page 67, the number is reported in the document as the -- under the mostly legal truck scenario, there's a range there. And it does report in this document 31 latent cancer fatalities to the exposed population. The number that's reported in the document and on the table here under maximally exposed individuals is .002 to .013. And in the document it appears as though that represents the probability and not an actual latent cancer fatality number. Above it appears as though the actual latent cancer fatality number is more in the range of 31. So what are we reporting in this table? It's not really clear to me.

Further, it's interesting to me that in other places in this table actual whole numbers are recorded, and they seem to be consistent with the LCF described in the document and not a probability. So I find it odd that it may have been reported as a probability in this particular spot in the table.

One other thing that leaves me a little bit suspicious is, if you go over to the column under the no-action scenarios, of course there's no impact under transportation. So it almost appears to me as though there was an attempt to minimize the appearance of fatalities under transportation by using a figure which is a probability and not an actual latent cancer fatality number. So I'm kind of concerned about that, that we're not really communicating on a first glance what's there.

How is the MEI, the maximally exposed individual calculation done? Well, here again, on this table on page 277 [2-77], I tried to find the figure for the LCF under the population, the .02 to .07. I tried to find that in the document. I had a lot of trouble with it. I've looked in the Appendix J under that section. I've looked in the section where it talks about transportation impacts for accidents. I'm not really finding any. But actually there is a number here that looks like it might be pertaining to it, and then I try to find a calculation for this.

And I want to point something out right here. I teach chemistry, I teach science myself, and in my 101 class I tell the students, whenever you report a number in a table, you need to show clearly how you calculate that number. And this is the idea of communicating information. This is always a very important aspect of science. In my opinion, this is not clearly communicating what's happening. It took me in the past 45 minutes [to] an hour trying to find this figure and where it came from. Not too easy. I know eventually I'd be able to figure it out.

But I'm thinking in terms of the average public that maybe has a little less experience working with figures. It should be a lot more clear. There should be a simple calculation so people can see exactly where the number came from. That is not communicated to the public. That's frustrating to the public. If I were not someone who is more into numbers, I would probably give up on it. And to me, that fails in what the charge of this document is supposed to do.

This is only one example of this. There are many examples which will be in the written comments on this. But this is where I feel the document really fails. As an instructor, it's insulting. I tell my students, you've got to report your numbers. You've got to show your calculations. It should be clear to a man on the street. And yet here it is here. It's like my teachings are being countermanded publicly.

So in a way I'm kind of insulted by that. I wish it were better communicated. And I think that's a very important principle. Everybody needs to understand the basics of this document, and that table is really significant because it's in the summary. A lot of people only look at the summary. It's very important. I think we need to address that.

Response

Table 2-7, on page 2-77 of the Draft EIS, summarized impacts at and around the repository (and the No-Action Alternative); including transportation impacts for the State of Nevada. National transportation impacts were included in Table 2-8.

The explanation of latent cancer fatalities in this and other summary tables has been clarified so the impacts to the reasonably maximally exposed individual are explained as the "probability of a latent cancer fatality" while impacts to an exposed population are the "number of latent cancer fatalities" in that population.

DOE agrees that misunderstandings of this type are frustrating. The summary tables in the EIS have been revised so it is clearer that this table is for repository and no-action impacts and the following table is for impacts from transportation.

7.5.7 (6088)
Comment - EIS001469 / 0007
I think that what has happened over the years is that radiation standards have been lower and lower and lower over the years. My interpretation of that is, as the body of knowledge increases we're beginning to see more and more ways that radiation impacts us. This document does not address that part of it, either. Over time I think it will become more and more important.

Response
Over the years, the levels of occupational radiation exposure considered acceptable have been reduced significantly. Except in the very early years, these reductions occurred not because of observed health effects but rather because of improved control technology and better understanding of the risks associated with radiation exposure (DIRS 155764-Moeller 1997). Occupational radiation protection standards have remained at about 5 rem per year since about 1965, when the potential for somatic effects (cancer) became the basis for radiation protection standards. Before that, the basis was for possible hereditary effects in humans, based on a 1927 report on experiments with *drosophila* flies. Earlier than that, following the discovery of X-rays in 1895, the basis for standards was prevention of acute exposure effects. Moeller (DIRS 155764-1997) discusses the evolution of radiation protection standards.

Recommendations for limiting dose to the public were developed much later than occupational limits (mainly because the potential for public exposure did not exist until use of radioactive material became more widespread after development of nuclear energy) and have remained in the range of 100 to 500 millirem per year. The current Nuclear Regulatory Commission dose limit for a member of the public is 100 millirem per year, set in 1991. As a point of reference, the Environmental Protection Agency and Nuclear Regulatory Commission individual radiation protection standard for long-term performance of the proposed repository is 15 millirem per year.

7.5.7 (6145)
Comment - EIS001654 / 0022
Page S-45. Occupational and Public Health and Safety

Much has been said at public hearings and many comments are likely to be submitted regarding radiological impacts. It often seemed to us that opponents have made statements objecting to either building a repository in Nevada or anywhere or transporting nuclear waste at any time by any means. Often the statements were made without factual support and served to add to the fear that many seem to have of radioactive materials of any kind under any conditions. DOE has provided a helpful presentation of knowledge on this difficult to understand subject. While much of the data that is provided in the DEIS throughout the document is extensive, it may be studied by few and understood by even less. We encourage DOE and EPA to continue the public education on the subject of radiological safety so that more will understand the subject matter and become better able to tell the difference between fact and myth.

This section refers to radiological impacts to workers and the public for various thermal load levels in the repository. Those risks are summarized in the summary in terms of latent cancer fatality increases to various populations. However, we found no discussion and linkage to dose-based standards that have been the subject of different positions by the U.S. Environmental Protection Agency (EPA) and the NRC [Nuclear Regulatory Commission]. The applicable standard for dose limits has not been established for the Yucca Mountain repository. If and when a standard is set it should be explicitly addressed in this section and in other sections of the FEIS.

While there has been much public speculation and expressions of alarm over radionuclide transport during the 10,000 year performance period and beyond, such concerns are based on levels of uncertainty that are difficult to prove or disprove. Likewise, there has been much concern and comment on radiation exposure during transportation to the repository even though the dose estimates provided are very small. Yet, there may be more direct exposure risks that have not drawn as much public notice. The latent cancer risks to repository workers during pre-closure period are given (page S-46) as 3-4 fatalities depending on thermal loads. This compares with one latent cancer fatality forecast (page S-48) among the general public during the 9,900 years following closure. If the comparison is correctly made, great care needs to be taken to protect worker safety during the pre-closure period. We would expect that the burden would be with DOE to demonstrate a sound radiological worker safety program in the operating license application with the goal of minimizing worker radiological risks.

Response

In the Nuclear Waste Policy Act of 1982, Congress found that State and public participation in the planning and development of repositories is essential to promote public confidence in the safety of disposal. DOE believes that its approach to the public involvement process is consistent with the National Environmental Policy Act, the Council on Environmental Quality, DOE regulations, and the intent of the Nuclear Waste Policy Act. A major element of the Yucca Mountain Project has been to ensure stakeholders, the media, and the public have an opportunity to participate in and acquire the information about the project that they need to make informed decisions. This effort is focused on building and maintaining relationships with stakeholders, the public, and media through regular interaction and provision of project information and educational opportunities. The program develops public information products, including permanent and portable field exhibits, information materials, models, audiovisuals, electronic media, publications and public outreach announcements. These public information sources are available at science centers in Las Vegas, Pahrump, and Beatty, Nevada; on the Yucca Mountain and DOE Office of Civilian Radioactive Waste Management Web internet sites at *http://www.ymp.gov* and *http://www.rw.doe.gov*; through public meetings and hearings on Yucca Mountain-related topics and during public tours of the Yucca Mountain site, as well by specific inquiries and requests for information and models, audiovisuals, electronic media, publications and public outreach announcements. Additional information on Yucca Mountain public outreach activities can be obtained by calling 1-702-295-1312 or 1-800-225-6972.

In addition, Appendix F of the Final EIS has been revised and expanded to include, in addition to human health impacts resulting from exposure from radioactive and toxic materials, a discussion of natural and manmade risks that are experienced in everyday life and a comparison with potential risks associated with storage, transportation, handling and disposal of spent nuclear fuel and high-level radioactive wastes. DOE expects to continue its public education programs related to health risks from exposure to ionizing radiation.

The Environmental Protection Agency had not finalized its environmental radiation protection standards for Yucca Mountain (released in draft at 64 *FR* 46976, August 27, 1999) when DOE published the Draft EIS. The results described in the Final EIS address the final Agency standards (40 CFR Part 197) promulgated in 2001 and include other information that might be of interest to the public and to the decisionmakers.

Radiological and industrial safety are high priorities within the DOE complex. The Department's goal is to promote safety of workers as well as the public and the environment. Chapter 11 of the EIS identifies the major requirements that could be applicable to the Proposed Action. With regard to protection of workers and members of the public and the environment against undue risk from radiation, the tables in Section 11.3 and Section 11.4 list the applicable DOE Orders and Federal regulations, including Orders 5400.1, 5400.5, and 10 CFR Part 835. The Department expects applicable portions of these regulations to be incorporated into the Nuclear Regulatory Commission license that must be issued prior to construction, operation and monitoring, and closure of a monitored geological repository.

7.5.7 (6318)

Comment - EIS001083 / 0006

As proposals are considered, whether they be for expansion of on-site storage, the creation of private central storage facilities, establishment of a federal interim storage or the emplacement of a permanent nuclear waste repository at Yucca Mountain, we must continue to utilize sound scientific and technical methods to ensure the safety of all Americans. The protection of our citizens and neighborhoods must be our foremost consideration when reviewing any proposal.

Response

Thank you for your comment.

7.5.7 (6359)

Comment - EIS001586 / 0002

One of the things that we are very concerned about with the nuclear waste, is that it is biocumulative and people get it in small amounts in products and they don't realize it's dangerous. And, as I say, I have got this whole thing, what I am talking about and other things I have published policies, Too Hot to Handle, Radioactive Waste Policy is Dangerous. They've put in – you've put in something saying below regulatory concern. Well, that cumulative, and some of the things that are below regulatory concern are dangerous.

Response

The calculation of potential radiation doses considered bioaccumulation, or environmental accumulation of radionuclides, regardless of the level of radionuclide released. This potential is included in the dose factors and methods described in Section G.2.4.1 of the EIS for repository operations and in Sections I.2.9 and I.4.4.6 for long-term performance. DOE estimates that the most likely outcome from potential exposure to ionizing radiation from the Yucca Mountain Repository during operations and the 10,000-year postclosure period would be no adverse health effects in the surrounding population.

The Environmental Protection Agency has responsibility for setting generally applicable standards for Yucca Mountain. The Nuclear Regulatory Commission has responsibility for modifying technical standards for the repository to be consistent with the Environmental Protection Agency standards. The Environmental Protection Agency has established final regulations at 40 CFR Part 197. This regulation establishes individual protection and human intrusion standards requiring that DOE demonstrate that there is a reasonable expectation that for 10,000 years after disposal, the reasonably maximally exposed individual would receive no more than an annual committed effective dose of 15 millirem per year for Yucca Mountain. This level of exposure would, using the recommended risk factors discussed above (0.0005 latent cancer fatality per rem or 1,000 millirem), would represent a risk of contracting a fatal cancer of 8 chances in 1 million for one year of exposure or about 5 chances in 10,000 for a lifetime (70 years) of exposure. For comparison, based on the most recent statistics, individuals living in the United Stated have about a 1 in 4 of dying of cancer from all causes (DIRS 153006-Murphy 2000).

The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197 and represents an incremental lifetime risk of contracting a fatal cancer of less than 1 chance in 100 million (see Table 5-6). This level of risk is about 25 million times lower than the current risk of contracting a fatal cancer in the United States from all other causes.

Although low levels of radiation exposure are estimated to result from the proposed action to construct, operate and monitor, and close the proposed geologic repository and the EIS provides estimates of latent cancer fatalities that could result from these small doses, these estimates are provided primarily to inform the decisionmaking process by enabling a quantitative comparison of impacts between the alternatives evaluated in this EIS. In all cases, estimates of latent cancer fatalities resulting from very small doses summarized in the EIS should be viewed as conservatively high; in fact, the uncertainties and conservatisms associated with these estimates (Sections K.4.3.2 and F.1.1.5) are such that DOE believes that any adverse health impacts resulting from these exposures would be highly unlikely or nonexistent.

7.5.7 (6473)

Comment - EIS001632 / 0031

Page 3-82, second full paragraph: The DOE's value of 0.0005 latent cancer fatalities per person-rem is lower than the Federal Guidance level of 0.000575 latent cancer fatalities per person-rem (Table 7.3, page 174, Federal Guidance Report 13, "Cancer Risk Coefficients for Environmental Exposure to radionuclides," EPA 402-R-99-001, September 1999). Since DOE was one of the funding, reviewing, and approving agencies for this study, EPA recommends that the Federal guidance level be used.

Response
The Environmental Protection Agency recently published an age-specific risk factor of 5.75 chances in 10 million per millirem for fatal cancer (DIRS 153733-EPA 2000). However, DOE currently uses the value of 5.0 and 4.0 chances in 10 million per millirem for fatal cancer for members of the public and workers, respectively, as recommended by the International Commission on Radiological Protection (DIRS 101836-ICRP 1991). When recommending these risk factors, the International Commission on Radiological Protection also expressed the desirability, for purposes of radiation protection, to use the same nominal risk factors for both men and women and for a representative population with wide ranges in age. The Commission stated that although there are differences between the sexes and populations of different age-specific mortality rates, these differences are not so large as to necessitate the use of different nominal risk factors. However, the higher risk factor for members of the public compared to that recommended for workers accounts for the fact that children comprise a relatively large part of the population and are more sensitive to the effects of radiation (cancer induction) than adults. Although the embryo-fetus is more radiosensitive (with a radiation risk factor about two times that for the whole population) it is protected by the body of the mother and comprises a small part of the overall population. Pregnant women are not unduly radiosensitive, especially to low levels of radiation.

Both the Agency and DOE recognize that there are large uncertainties associated with these risk factors, as expressed by the National Council on Radiation Protection and Measurements comment on the result of their uncertainty analysis in the risk coefficients that " … show a range (90 percent confidence intervals) of uncertainty values for the lifetime risk for both a population of all ages and an adult worker population from about a factor of 2.5 to 3 below and above the 50th percentile value" (DIRS 101884-NCRP 1997). The Department believes that the 15-percent difference in these risk factors is well within other uncertainties and would provide little additional information to the decisionmaking process that this document informs. For these reasons, DOE will continue to use risk factors recommended by the International Commission on Radiological Protection in their National Environmental Policy Act documents.

7.5.7 (6577)
Comment - EIS001380 / 0009
Page F-11. The worker dosage analysis at Yucca Mountain makes the incorrect implicit assumption that workers are only exposed during the Yucca Mountain project. However, most of the permanent workers spend their full working lifetimes at nuclear sites and thus their probable lifetime exposures, including the intervals of their lives before and after being employed at Yucca Mountain, need to be factored into the risk estimates. The "double hit" hypothesis of cancerogenesis is now conclusively established. Thus, a worker could have suffered the initial hit at another nuclear site, and then get the critical second hit that leads to cancer formation at Yucca Mountain. Exposure and employment data should be readily available on Yucca Mountain workers. My guess would be that many have large cumulative radiation exposures that already increase their risk for cancers and other subthreshold radiation injuries.

Response
The EIS makes no assumption about worker's radiation exposures at other nuclear facilities either before construction or after closure but focuses on incremental exposures resulting from the Proposed Action and No-Action Alternative. However, it should be noted that like their counterparts who work in commercial nuclear facilities licensed by the Nuclear Regulator Commission, DOE worker occupational exposures are closely monitored and reported. Also, like their commercial counterparts, worker annual and lifetime occupational exposures are carefully tracked to ensure compliance with annual exposure limits codified at 10 CFR 835.202 (annual limits for commercial workers are codified at 10 CFR 20.1201). Lifetime exposure limits are strictly controlled and regulatory limits are codified for both commercial and DOE workers at 10 CFR 1206(e)(2) and 10 CFR 835.204(c)(2), respectively. These regulations require new employees to submit detailed annual and lifetime exposure histories provided by the appropriate Federal agency (DOE and the Commission) prior to receiving additional radiation exposure. Therefore, it is highly unlikely that any radiation worker at either DOE or Commission facilities would be allowed to continue working in a radiation environment if previous exposures had been determined to be above the regulatory limits.

In 1999, DOE and the Nuclear Regulatory Commission published reports that detailed occupational radiation exposure at DOE and commercial facilities. These reports show that in 1998, the average annual worker exposures at DOE facilities and NRC nuclear fuel cycle facilities were about 74 millirem and 230 millirem, respectively. For perspective, these occupational doses represent a fraction of the average dose received from natural background radiation in the United States (see Table 3-30 of the EIS).

7.5.7 (6582)

Comment - EIS001380 / 0010

Page F-12. How was the factor of 0.0004 latent cancer fatality per rem validated and derived? A source is given, but a brief rationale should be stated explicitly in the draft EIS. The secondary documents cannot be obtained in time to comment by Feb. 9. The statements are made that consideration of other "non-fatal cancers and severe genetic effects" of radiation exposure that "increases the total change by a factor of 1.5 to 5 compared to the change for latent cancer fatalities" is data that "as is the general practice for any DOE EIS, estimates of the total change were not included in the Yucca Mountain EIS." This policy should be reconsidered; it is absurd. Why this policy is justifiable scientifically needs to be stated explicitly. To this physician, the policy misleads the public as to the actual danger of radiation exposure -- does DOE believe death is the only legitimate concern of the public? I think not.

Response

As discussed in Section F.1.1.5, the risk conversion factors of 0.0005 latent cancer fatality per person-rem of collective dose for the general public and 0.0004 latent cancer fatality per person-rem of collective dose for workers, which DOE typically uses in its National Environmental Policy Act documents, are based on recommendations of the International Commission on Radiological Protection (DIRS 101836-ICRP 1991) and the National Council on Radiation Protection and Measurements (DIRS 101856-NCRP 1993). However, because adverse health effects have never been observed statistically in humans exposed to low doses of radiation, validation of these factors has not been possible in the classical sense. Rather, the factors are based on health effects observed in the high dose and high dose rate region (20 to 50 rem per year). Health effects were linearly extrapolated to the low dose region (less than 10 rem per year) using the linear no-threshold model. In general, the International Commission on Radiological Protection and the National Council of Radiation Protection and Measurements recommend this model, and some radiation protection professionals believe the model produces a conservative estimate (that is, an overestimate) of health effects in the low-dose region, which is the exposure region associated with the activities evaluated in the EIS.

Because validation of the risk factors has not been possible, estimates of impacts contain considerable uncertainty. According to the National Council on Radiation Protection and Measurements, the results of an analysis of the uncertainties in the risk coefficients "show a range (90-percent confidence intervals) of uncertainty values for the lifetime risk for both a population of all ages and an adult worker population from about a factor of 2.5 to 3 below and above the 50th percentile value" (DIRS 101884-NCRP 1997).

However, the National Academy of Science National Research Council stated that: "epidemiological data cannot rigorously exclude the existence of a threshold in the millisievert dose range. Thus the possibility that there may be no risks from exposures comparable to external natural background radiation cannot be ruled out. At such low doses and dose rates, it must be acknowledged that the lower limit of the range of uncertainty in the risk estimates extends to zero" (DIRS 100473-National Research Council 1990). In the United States, natural background radiation ranges from about 300 millirem per year.

Many adverse health effects have been attributed to exposure to ionizing radiation but have been observed in humans only at high doses or dose rates. However, for chronic low doses such as those predicted in the EIS resulting from the Proposed Action, the National Research Council Committee on the Biological Effects of Ionizing Radiation (BEIR III) has stated that cancer induction is considered to be the most important somatic effect (DIRS 153007-National Research Council 1980). The Committee went on to say that among the somatic effects of radiation other than cancer, developmental effects on the unborn child are of greatest concern (DIRS 153007-National Research Council 1980). The Committee also said that for somatic effects other than cancer and developmental changes (for example, cataracts, aging, and infertility), the available data do not suggest an increased risk with low-dose, low-energy-transfer exposure of human populations (DIRS 153007-National Research Council 1980).

However, to enable comparisons with fatal cancer risk, the International Commission on Radiological Protection suggested use of detriment weighting factors that consider the cure rate of nonfatal cancers and the reduced quality of life associated with nonfatal cancers and heredity effects (DIRS 101836-ICRP 1991). As discussed in Section F.1.1.5 of the EIS, because both of these life-detriment factors together would be less than half of the fatal cancer risk, DOE has chosen to estimate total cancer fatalities as the major potential health effect from exposure to radiation.

7.5.7 (6584)
Comment - EIS001380 / 0011
The CAIRS [Computerized Accident Incident Reporting System] database datasets are mentioned on pages F-15 and F-16 but the draft EIS does not state how or if the public has access to these data in a similar manner to its access to the EPA's [Environmental Protection Agency's] Internet-access CEDR database. This information should be footnoted in the EIS.

Response
The reference list at the end of Appendix F in the Draft EIS contains the information on the Computerized Accident Incident Reporting System (CAIRS) database. The information is available to the public through the DOE Office of Environment, Safety and Health Information Portal at http://tis.eh.doe.gov.

7.5.7 (6594)
Comment - EIS001380 / 0016
I found the elementary primer on radiation to be perfunctory and simplistic (although the facts were true in general) and missed the point. The primer and the analysis could and should have addressed all of the many proven adverse effects of radiation on human cells and tissues, not just cancer alone which is the tip of the medical iceberg. In the case of inhalation exposure, for example, pulmonary fibrosis and emphysema as well as cancer should have been addressed. Radiation biology is far more advanced than the draft EIS would indicate. No where is mentioned, as another example, that radiation can damage and kill cells by apoptosis without damaging nucleic acids. Whole sections of current radiation biology scientific journals are devoted to this topic alone. I got the impression that physicians knowledgeable about human radiation pathologic effects probably had no part in writing this document. I find this to be a very disappointing oversight if one's intent were to accurately analyze possible adverse scenarios of an accident while transporting high-level and spent nuclear fuels.

Response
DOE agrees that the information provided in Appendix F related to radiation effects is simplistic. Space limitations and the intended lay audience preclude a detailed review of the health effects of ionizing radiation or details of cellular radiobiology.

DOE agrees that many adverse health effects have been attributed to exposure to ionizing radiation. However, for chronic low doses such as those predicted in the EIS resulting from the Proposed Action, the National Research Council Committee on the Biological Effects of Ionizing stated in the BEIR III report that cancer induction is considered to be the most important somatic effect (DIRS 153007-National Research Council 1980). The Committee went on to say that among the somatic effects of radiation other than cancer, developmental effects on the unborn child are of greatest concern (DIRS 153007-National Research Council 1980). In addition, the Committee said that for somatic effects other than cancer and developmental changes (e.g., cataracts, aging, and infertility), the available data do not suggest an increased risk with low-dose, low linear energy transfer (LET) exposure of human populations (DIRS 153007-National Research Council 1980).

For these reasons, DOE has selected, for use in the EIS, dose-to-risk factors recommended by the National Council on Radiation Protection and Measurements (DIRS 101856-NCRP 1993) and the International Commission on Radiological Protection (DIRS 101836-ICRP 1991) for estimating the risk of latent cancer fatality from exposure to ionizing radiation. These factors were developed based on the linear no-threshold hypothesis, which assumes that adverse health effects could occur from exposure to ionizing radiation regardless of how small the dose.

In addition to fatal cancers, as the commenter has pointed out, experts generally recognize that other health effects could result from exposure to radiation. Therefore, to enable comparisons with fatal cancer risk, the International Commission on Radiological Protection (DIRS 101836-ICRP 1991) suggested use of detriment weighting factors which take into consideration the curability rate of nonfatal cancers and the reduced quality of life associated with nonfatal cancer and heredity effect. However, as discussed in Section F.1.1.5, since both of these life-detriment factors, when taken together, are less than half of the fatal cancer risk, DOE has chosen to estimate total cancer fatalities as the major potential health effect from exposure to radiation.

With regard to noncarcinogenic diseases of the lung, according to Dr. John B. Little, M. D., Simmons Professor of Radiology and Director of Radiobiology, School of Public Health, Harvard University (DIRS 157321-Rollins 2000), "Pulmonary fibrosis [and emphysema] is observed only at high radiation doses, such as are experienced in radiation therapy. Pulmonary fibrosis is not observed at low or chronic levels of radiation dose."

DOE believes that the studies of apoptosis (as were the studies of the mechanisms of radiation interactions in human cells and tissues) are designed to provide a better understanding of the sequence of events that lead to the development of cancer. However, knowledge of the details of the interactions of radiation in human cells and tissues would be of little value in developing scenarios for evaluating the potential impacts from, for example, transportation accidents on human populations. What is important is the amount and form of the radioactive material that might be released, the pathways through which it might cause exposures to nearby population groups, and the doses that might occur that could result in adverse health effects.

7.5.7 (6684)
Comment - EIS001632 / 0084
Page 14-22, definition of "maximally exposed individual": The last sentence of this definition equates the maximally exposed individual (MEI) with the "reasonably maximally exposed individual (RMEI)," a term used in the recently proposed 40 CFR Part 197 (see 64 *FR* 46988 and 47014/47015, August 27, 1999). These two terms are very different. The dose incurred by the MEI is calculated by using the most conservative values (i.e., producing the highest dose) for all parameters needed to calculate the dose to an individual. The dose incurred by the RMEI, on the other hand, assumes that one or a few parameters are at their maximum or most conservative values while the others are at their average values.

Page 14-29, definition of "reasonably maximally exposed individual"

Response
DOE has revised these definitions in the Final EIS. Chapters 4, 6, and 7 now use the term "maximally exposed individual," and Chapter 5 uses "receptor." The receptor is equivalent to both the "reasonably maximally exposed individual" defined in the Environmental Protection Agency's regulations at 40 CFR Part 197. This change reflects the regulatory definitions and requirements for long-term performance recently promulgated by both agencies.

7.5.7 (6870)
Comment - EIS001466 / 0013
We could see Amargosa Valley in the distance, the farming community downstream of Yucca Mountain where the highest doses will be coming out into the water. People will be drinking that water, using it to irrigate their crops.

And the biomagnification of radioactivity is something that I've experienced in Chernobyl. My wife and I have spent some time over there. We have a lot of friends over there. And to hear them talk about if they only had a Geiger counter they could take it to the marketplace with them, but of course it would be a year's salary to buy that anyway. But that will be the main source of contamination to people downstream Yucca Mountain is the food that they eat will be contaminated with radionuclides.

Response
DOE is aware of the environmental accumulation or "biomagnification" of radionuclides or other substances that could occur. The calculation of potential radiation doses for individuals and the population of Amargosa Valley considered the potential for environmental accumulation, for example, in uptake of radionuclides by plants and animal products that residents could consume. This potential is included in the dose factors and methods described in Section G.2.4.1 of the EIS for repository operations and Section I.4.4.6 for long-term performance. The experience at Chernobyl is considerably different from anything that would reasonably be expected to occur around Yucca Mountain and in the Amargosa Valley, both in the type of release and levels and pathways of exposure. DOE recognizes that people living in the Amargosa Valley have concerns about the potential for low levels of radioactivity in groundwater from radioactive material disposed of at Yucca Mountain. The analysis in the EIS

shows that releases of this type would be well below regulatory standards. DOE expects no adverse radiation-related health impacts to individuals in Amargosa Valley or elsewhere around Yucca Mountain.

7.5.7 (6894)
Comment - EIS001608 / 0001
I thought I heard someone earlier refer to low dose, the effect of low dose, which brought to mind the work of John Golfman. I am a little surprised his name hasn't been brought up. He's the renowned scientist, doctor in California who has shown that low doses can be more harmful than higher doses.

His work impacts particularly this notion of the chest X-ray, and that's precisely what Dr. Golfman has been addressing in terms of breast cancer, which is one of the big problems. So I wouldn't dismiss a chest X-ray. The problem is these doses usually aren't measured.

Response
The views of Dr. John Gofman on the effects of exposure to low levels of ionizing radiation are unsupported by independent scientific research and have not been accepted by the scientific community at large. His theories have also been generally repudiated in the courts. DOE cannot accept these views until they have received independent scientific peer review and been accepted into the mainstream body of scientific literature.

7.5.7 (6899)
Comment - EIS001608 / 0003
I know someone whose grandchildren went to school in Colorado, one of those school buildings, the foundation of which was built with uranium mine tailings. I know the story of Colorado's use of mine tailings for concrete, house foundations, Grand Junction Shopping Mall, and I worry. I mean, there's nothing I've heard today that says when you talk about using concrete as part of, say, a repository, how do I know you aren't going to use some of those mine tailings? It doesn't sound like a good idea, but when you are desperate to get rid of some of this stuff, who knows, it might happen.

Now, we have been accused of having an irrational fear of radiation, and that is totally unacceptable. It's abnormal not to be more than extremely respectful of nuclear radiation.

Response
In some locations such as Grand Junction, uranium mill tailings were used as fill around the foundations of buildings and for other purposes. Although most of the uranium had been removed, the uranium decay products including radium-226 remained in the tailings. Radium-226 decays to the noble gas radon-222, which diffused through the foundations and led to elevated radiation exposures of the residents to radioactive radon decay products. This problem resulted from the use of this radioactive material in near-proximity to residences and buildings, where people could be readily exposed. Disposal of this same material in the isolated environment of the geologic repository would be considerably different. However, uranium mill tailings would not be disposed of at Yucca Mountain. These mill tailings are already being successfully remediated near the locations where they were originally generated.

DOE agrees that the potential for ionizing radiation exposure and health effects should be treated in a respectful manner. Decisions need to be made with a clear understanding of the potential risks and benefits. DOE is committed to meeting the regulations regarding dose from ionizing radiation, and keeping radiation exposures resulting from preclosure activities at the proposed repository as low as reasonably achievable.

7.5.7 (7267)
Comment - EIS001832 / 0015
Appendix K of the DEIS states that the impacts of the radiological population doses estimated in the DEIS "should be viewed as conservatively high; in fact, the uncertainties are such that **the actual level of impact could be zero**." [emphasis added] This fact should be included in the Summary and Volume I of the DEIS. Further, this conservatism in the estimates of the radiological impact should be more clearly identified and explained in plain language.

The following statement from Appendix K is one example of such a clarification, that needs to be brought forward and integrated into the conclusion of the DEIS to establish appropriate context, is:

"The dose-to-risk conversion factors typically used to estimate adverse human health impacts resulting from radiation exposure contain considerable uncertainty. The risk conversion factor of 0.0005 latent cancer fatality per person-rem of collective dose for the general public is based ... on health effects observed in the high dose and high dose rate region. Health effects were extrapolated to the low-dose region (less than 10 rem per year) using the linear no-threshold model. This model is generally recommended by the International Commission on Radiological Protection and the National Council on Radiation Protection and Measurements, and most radiation protection professionals believe this model produces a conservative estimate (that is, an overestimate) of health effects in the low dose region..."

In clarifying this statement, DOE should recognize that the use of the linear no-threshold dose response model is conservative and, thus, DOE used that assumption in assessing human health effects associated with the proposed action. The view that the dose response model assumed results in a conservative estimate of the human health impacts is an important factor in explaining the radiological consequences of the proposed action to members of the public. This conservatism in the calculated effects should be clearly stated in the Summary and in Volume 1 of the EIS and not only in an appendix.

Response
DOE agrees that this information is important and deserves expanded explanation in the EIS. Therefore, the Department has revised the "Radiation Primer" in Appendix F and included a discussion of uncertainties in impact estimates. In addition, DOE has revised the information in Chapter 4, where the EIS first discusses radiation-related health impacts. The Summary and Chapters 5, 6, and 7 now include a more limited discussion.

7.5.7 (7451)
Comment - EIS001969 / 0008
If we are interpreting Table 4-34 (page 4-59) correctly, over a 70 year life span a person living within 12 miles of the repository would receive a life time radiation dose of between 38 to 100 millirems from the repository depending on the thermal load scenario used. Is this correct? If so, it is significantly lower than the NRC's [Nuclear Regulatory Commission's] standard of 100 millirems per year at abandoned mines after reclamation. We believe that it is unusual that a person residing near this repository would receive less radiation than would one who lived near many other areas containing less radiation, such as abandoned mine sites. If our interpretation is incorrect, and the correct dose rate is between 38 and 100 millirems; per year, then the low thermal load matches the NRC standard. Perhaps this figure needs to be reevaluated in the final EIS to clear up this ambiguity.

Response
The interpretation is correct. In the Draft EIS, the maximally exposed individual would receive an estimated dose of 38 to 100 millirem over 70 years. Table 4-35 (Footnote c) and Section 4.1.7.5.3 of the Draft EIS explain this dose. Section 4.1.2 of the EIS discusses the highest potential annual dose would be less than 2 millirem per year.

Exposure scenarios at reclaimed uranium mines or mills are much different from the potential exposure near the proposed repository at the Yucca Mountain site. The key differences at Yucca Mountain would be the lack of high uranium and uranium decay product source material, lack of tailings with enhanced concentrations of uranium decay chain radionuclides, and the location of the potential public dose receptor at the boundary of the controlled area (15 millirem per 40 CFR Part 197). Further, potential public exposures at Yucca Mountain would be held to a much more rigorous standard than 100 millirem per year. The discussions in Sections 4.1.2 and 4.1.7, along with the supporting information in Section G.2, explain potential public radiation doses.

7.5.7 (7584)
Comment - EIS001969 / 0036
Page 3-79, Section 3.1.8 Occupational and Public Health and Safety.

The radiological hazards and their consequences were discussed in a concise way such that the average citizen can draw conclusions about the risks of the proposed and alternative actions. The background information that was provided to develop an understanding of ionizing radiation and the hazards/risks was especially helpful.

Response
Thank you for your comment.

7.5.7 (7652)
Comment - EIS001928 / 0010
Pg. S-48 – 3rd and 4th para. – This section on health impacts is very confusing. In the 9,900-year analysis (3rd para) the maximally exposed individual (MEI) would be expected to receive only 1.3 mr/yr. [millirem per year] at a distance of three miles. Then, the million-year analysis (4th para.) predicts an MEI peak dose rate of 9,100 millirem at a three-mile distance occurring 320,000 years after closure. 1.3 mr vs 9,100 mr! Is the 9,100 value per year? Or spread out over the 320,000 years? If the latter is the case, then what is the relevance? An MEI will live only a tiny fraction of 320,000 years whether he contracts a radiation-induced cancer or not.

Furthermore, after 9,900 years (and even much sooner), all the relatively short-lived fission products will have decayed away. And in 320,000 years, even that widely-feared and misunderstood bugbear, plutonium, in its common guises of Pu 239, 240 and 241 will have disappeared.

So, really, what is one to make of this section on health impacts. What does it all mean in a practical sense?

Response
Dose rates in the EIS are in millirem per year. DOE has revised the summary so it is clear these are annual doses. Section 5.4 contains additional information on the radionuclides that would contribute to the dose. Since publication of the Draft EIS, the Environmental Protection Agency has finalized their regulations at 10 CFR 40.197 applicable to a Yucca Mountain repository. These regulations require DOE to make estimates of the annual dose to the reasonably maximally exposed individual for 10,000 years following closure of the repository. In addition to the 10,000-year regulatory period, the regulations require estimates of peak dose through the period of geologic stability, which is assumed to be 1,000,000 years for the Yucca Mountain site.

The Environmental Protection Agency, in promulgating the Yucca Mountain environmental protection standards (40 CFR Part 197), recognized that with the current state of technology it is impossible to provide a reasonable expectation that there would be “zero” releases over 10,000 years or longer. Therefore, standards have been established that the Environmental Protection Agency believes provide comparable protections to those of other regulated activities related to nonradioactive wastes. These standards do not require complete isolation of the wastes over the 10,000-year compliance period. The goal of a performance assessment for Yucca Mountain supporting the Site Recommendation decision and later licensing (if the site was recommended), is to evaluate whether the repository would be likely to meet these standards. The goal of performance analysis in the EIS is to project possible impacts using modeling technology similar to that used for the long-term performance assessment.

The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197.

In addition to the 10,000-year compliance period, DOE has evaluated potential impacts for the period of geologic stability at the repository (that is, 1 million years). This evaluation was performed, in accordance with 40 CFR Part 197, to gain insight into the very long-term performance of the repository and thus provide information for the decisionmakers in making both design and licensing decisions. These results show a mean peak dose rate that is much lower than those resulting from natural background radiation (see Table 5-8 for details).

With respect to groundwater protection standards set forth in 40 CFR Part 197.30, estimated groundwater concentration during the 10,000-year regulatory are hundreds of thousands of times lower than the regulatory limits (see Table 5-9).

Although low levels of radiation exposure are estimated to result from the proposed action to construct, operate and monitor, and close the proposed geologic repository and the EIS provides estimates of latent cancer fatalities that could result from these small doses, these estimates are provided primarily to inform the decisionmaking process by enabling a quantitative comparison of impacts between the alternatives evaluated in this EIS. In all cases, estimates of latent cancer fatalities resulting from very small doses summarized in the EIS should be viewed as conservatively high; in fact, the uncertainties and conservatisms associated with these estimates (see Sections K.4.3.2 and F.1.1.5) are such that DOE believes that any adverse health impacts resulting from these exposures would be highly unlikely or nonexistent.

7.5.7 (8085)
Comment - EIS001653 / 0064
Table 4-35 what does the information in this table [radiological consequences of the repository operations] mean? Are the results adverse?

Response
As discussed in Section 4.1.8.1 of the EIS, Table 4-35 lists radiological consequences of repository operations accident scenarios for median (50th-percentile) meteorological conditions The results in Table 4-35 indicate the highest probability of a latent cancer fatality to the maximally exposed offsite individual who receives the calculated dose would be 0.000016. The number of latent cancer fatalities in the exposed population would be 0.46. The fact that these values are far below 1 indicates that the increased risk of contracting a fatal cancer is very small.

In addition, estimates of latent cancer fatalities resulting from very small doses summarized in the EIS should be viewed as conservatively high; in fact, the uncertainties and conservatisms associated with these estimates (see Appendix K, Section K.4.3.2 and Appendix F, Section F.1.1.5) are such that DOE believes that any adverse health impacts resulting from these exposures would be highly unlikely or nonexistent.

7.5.7 (8260)
Comment - EIS001950 / 0003
Nevadans and persons living in the path of the aquifer downstream of Yucca Mountain should be exposed to a dose of zero additional radiation.

Response
The goal of geologic disposal is to concentrate and isolate spent nuclear fuel and high-level radioactive waste in a relatively small area for a very long time. DOE intends to achieve isolation of the wastes in the proposed repository by using a system of engineered barriers and by locating the repository in the geologic setting of Yucca Mountain. However, it is always possible to conceive of circumstances (both manmade and natural) that, given the inherent uncertainties associated with long-term projections, could result in the release of radioactive materials to the accessible environment. It is also likely that eventual release of some material is inevitable because all systems will degrade given sufficient time.

The Environmental Protection Agency standards (40 CFR Part 197) recognize that, with the current state of technology, it is impossible to provide a reasonable expectation that there would be no releases over a 10,000-year or longer time frame. Therefore, the Agency has established public health protection standards it believes provide comparable protections to those of other activities related to radioactive and nonradioactive wastes. These standards do not require complete isolation of the wastes over the compliance period (that is, 10,000 years) or the period of geologic stability (1 million years). The goal of a performance assessment for Yucca Mountain is to evaluate whether the repository would be likely to meet these standards and thus provide adequate protection of human safety and the environment.

The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197.

In addition to the 10,000-year compliance period, DOE has evaluated potential impacts for the period of geologic stability at the repository (that is, 1 million years). This evaluation was performed, in accordance with

40 CFR Part 197, to gain insight into the very long-term performance of the repository and thus provide information for the decisionmakers in making both design and licensing decisions. These results show a mean peak dose rate that is much lower than those resulting from natural background radiation (See Table 5-8 for details).

7.5.7 (8363)
Comment - EIS001873 / 0047
P. 4-47. It should be noted that death is one adverse non cancer effect of silicosis.

Response
There have been historical instances where acute exposures of workers to extremely high concentrations of crystalline silica dust have resulted in fatalities. Current standards for crystalline silica have been established to prevent silicosis in workers. The Federal Occupational Safety and Health Administration has established Permissible Exposure Limits and the American Conference of Governmental Industrial Hygienists have established Threshold Limit Values for these forms of silica. Because of these established limits on exposure of workers to crystalline silica, such an effect at Yucca Mountain would be highly unlikely.

7.5.7 (8456)
Comment - EIS000817 / 0136
I guess I don't like a hypothetical person and use of averages, etc. To me, no amount of added radiation to a person is acceptable, and why people in Nevada should be targeted, is unfair. Will people in that area be given pills to counteract any unexpected releases? Will those pills to protect [the] thyroid from iodine-129, etc. be stockpiled in the area and distribution plans be public? They should be. If not, why not? I'm going to skip over a lot of this on doses, for I don't think you actually can predict them at all. The VSC-24 [Ventilated Storage Cask, Model 24] cask for example was touted as having such low doses. Well, with all the problems -- UT [ultrasonic] testing, etc., and now they want to reduce shielding on the transfer cask to lower the weight in order to put in BPRAs [burnable poison rod assemblies]. What happened to ALARA [as low as reasonably achievable] anyway? Promises were broken on dose rates. I don't believe predictions of this sort -- they don't see reality and they expect a perfect world with no human error. Expect the unexpected. Murphy's Law is in effect. "What can go wrong, will go wrong," as Mr. Haughney of NRC [Nuclear Regulatory Commission] said after the VSC-24 explosion. And it continued to do so.

Response
DOE used a hypothetical reasonably maximally exposed individual in estimating doses to an individual. This hypothetical individual was assumed to have lifestyle characteristics that tend to maximize potential radiation dose. Average values were not used. The actual dose received by an individual probably would be lower than the DOE estimates. The pills noted in this comment are stable iodine pills, sometimes taken so that stable iodine goes into the thyroid rather than radioactive iodine. Releases of radioactive iodine would be highly unlikely and would be extremely small, even in accident cases (see Section 4.1.8) during repository operations. Some very small releases of iodine-129 could occur long term and enter the groundwater. The potential radiation dose from radioactive iodine would be very small and unlikely to result in adverse health impacts.

On May 28, 1996, a hydrogen gas ignition occurred during the welding of the shield lid on a ventilated storage cask (VSC-24) multiassembly sealed basket at the Point Beach Nuclear Plant. The gas ignition displaced the shield lid, leaving one edge about 7.6 centimeters (3 inches) higher than normal. The source of the hydrogen was oxidation of zinc in a coating designed to prevent corrosion when in contact with borated water in the spent nuclear fuel pool. The gas ignition caused no injuries, no radiological releases, and no apparent damage to the spent nuclear fuel, storage cask, or the reactor facility itself (NRC Bulletin 96-04 – Spent Fuel Casks, *http://www.nrc.gov/OPA/reports/bl9604.htm*). While it is not possible to predict in advance any particular sequence of events constituting an accident, the DOE performs extensive safety analyses of transportation, operation, and postclosure conditions to identify accident scenarios and resultant consequences. Adherence to the as low as reasonably achievable principle is an integral part of DOE radiation safety programs.

7.5.7 (8613)
Comment - EIS001256 / 0009
Dose calculations do not account for the additive, multiplicative and synergistic relationships of radiological and other biologically hazardous pollutants, factors and conditions that ultimately will affect recipients.

Response
The EIS discusses the risks of exposure to ionizing radiation and hazardous chemicals separately where such exposures could exist. A good scientific foundation for adding the risks of exposure to radiation and chemicals does not currently exist, even if target tissues might be the same, because exposure pathways and cellular and molecular mechanisms of cancer induction can differ.

DOE expects no adverse radiation-related health effects from Yucca Mountain activities. The levels of radiation exposure estimated to occur from Yucca Mountain operations are very low, less than 2 millirem per year for the highest annual exposure (see Sections 4.1.2 and 4.1.7). No hazardous substance exposure is expected during operations. Low levels of exposure to criteria pollutants (Section 4.1.2) are expected to have no health impacts.

Radiation exposure would be even less during the first 10,000 years of the postclosure period (see Section 5.4). There is some potential for exposure to hazardous substances during this period (see Section 5.6) but it is similarly very low. Again, no health impacts would be expected.

7.5.7 (8637)
Comment - EIS001256 / 0019
The Precautionary Principle must be the over-riding principle within this decision making process. This Precautionary Principle says that where there are threats of serious or irreversible damage, a practice or substance should be treated as though it is unsafe, until it is proven to be safe. The potential damage to people and to the environment here is immense. The threat stretches from the point of origin of the nuclear waste, across the entire continent, along several rail and highway routes. There is no way that anyone could ever prove that any of the practices involved in this plan are safe. Therefore, according to the Precautionary Principle, this group of practices must be considered inherently unsafe and should not be pursued.

There is too much at stake here – millions of people, thousands of tons of high level waste, thousands of miles of highways and rail, millions of acres of land where intricate suites of plants, animals, and people live. Radioactive contamination and its effects are persistent, toxic, and liable to bioaccumulative even when there is little scientific evidence to prove the strength of the causal link between release and effects. In the absence of scientific certainty, the Precautionary Principle implies that actions must be taken that will protect people and the environment from that which must be assumed to be unsafe. Certainly we have here the threat of serious and irreversible damage. It then follows that the DOE must:

Halt our relentless drive for approval of the inadequate Yucca Mountain site;

Explain to the Congress why we should not proceed.

Give serious reconsideration to finding the least dangerous, most equitable methods of retaining control of all radioactive wastes in a manner that will best assure that future populations will have an opportunity equal with our own to be able to continue to maintain control for the duration of its hazardous lifetime.

The DOE must take these actions to protect the nation's people and our natural heritage from the hazards of high level nuclear waste, for our environment, for our families, and for our future.

Response
DOE also believes that precautionary measures should be taken especially where cause and effect relationships are not fully understood. For example, DOE uses the linear no-threshold hypothesis for estimating effects of exposure to low levels of ionizing radiation, where there is no definitive scientific evidence that ionizing radiation has an adverse effect. The linear no-threshold hypothesis states the stochastic (that is, effects having a probability of occurrence rather than a threshold) cause and effect relationship of radiation noted at high doses and dose rates, namely cancer, are also presumed to occur at low doses and/or low dose rates. For purposes of radiation protection, national and international advisory groups, including the National Academy of Sciences, National Council on Radiation Protection and Measurements, and International Commission on Radiological Protection have recommended that it is both prudent and conservative to apply high dose or dose rate evidence to those situations where low doses or low dose rates might be received. DOE and other federal agencies, including the Environmental Protection Agency and the Nuclear Regulatory Commission, have accepted the recommendations of these advisory

groups for purposes of radiation protection and for making estimates of the risk from ionizing radiation exposure, adopting the linear, no-threshold hypothesis for estimating health effects from exposure to low levels of ionizing radiation.

With regard to the comments about proving safety and considering actions inherently unsafe and not taking them until proven, and also using lack of full scientific certainty as a basis for taking no action, the National Academy of Sciences concluded that: " … [the] better safe than sorry … philosophy holds true only when unlimited resources are available to protect the public health and the environment. Once resources are acknowledged to be limited, overestimates of a particular risk are ultimately harmful to the public health because funds are diverted from larger risks to protect society from smaller risks. This diversion of funds ultimately will result in greater mortality than would have occurred if resources were spent in proportion to the amount of health benefit that would be achieved" (DIRS 154539-National Research Council 1995). The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197 and represents an incremental lifetime risk of contracting a fatal cancer of less than one chance in 100 million (see Section 5.4.2 of the EIS). This incremental level of risk is about 25 million times lower than the current risk of contracting a fatal cancer in the United States from all other causes and far below that which people consider important to their everyday decisionmaking process (see Section F.1.1.5 for a discussion on risk perspectives). DOE believes that the benefits of safely isolating spent nuclear fuel and high-level radioactive waste from the accessible environment far out weigh the small levels of additional risk associated with the long-term performance of the Proposed Repository.

With regard to the statement that DOE should stop efforts to gain approval for a repository at Yucca Mountain, Congress specifically directed the Secretary of Energy to characterize and evaluate the Yucca Mountain site for suitability as a geologic repository. Through the NWPA, Congress established a process that will lead to a decision by the Secretary of Energy on whether to recommend to the President approval of the Yucca Mountain site for the development of a repository. Therefore, consistent with the NWPA, DOE continues to characterize and evaluate the suitability of the Yucca Mountain site.

DOE believes that the information provided in the EIS on safely handling, transporting, and disposing of high-level radioactive materials and the protection of individuals and populations is consistent with the National Environmental Policy Act and sufficient to support the Secretary of Energy's determination whether to recommend the Yucca Mountain site for development of a repository.

7.5.7 (8797)
Comment - EIS001907 / 0025
Only 12 miles from Yucca Mt. lies numerous dairy and agricultural (including several organic dairies and farms) industries. One of these dairy's ships 30,000 gallons of milk per day to Los Angeles, was this taken into consideration in this document? I don't think that it was, and this is another reason to start the DEIS process over.

Response
In evaluating potential human health impacts of the Yucca Mountain Repository, DOE considered all exposure pathways, including agricultural and animal products such as milk, for residents of Amargosa Valley. The dose factors described in Section G.2.4.1 of the EIS for operations and Section I.4.4.6 for long-term performance include these pathways. DOE estimates that the most likely outcome from potential exposure to ionizing radiation from the Yucca Mountain Repository during operations and the 10,000-year postclosure period would be no latent cancer fatalities in the surrounding population. Chapter 5 addresses potential impacts to individuals outside the Yucca Mountain region from transported agricultural products, specifically from consumption of milk products produced by the dairies noted by the commenter. The dose to these individuals would be less than the estimated dose to the "reference individual" described in the EIS sections mentioned above.

7.5.7 (8833)
Comment - EIS000869 / 0010
Regarding S.3.1.2, paragraph seven, there is no recommendation as to which thermal load scenario is planned. I appreciate the attempts made to protect workers by creating a negative pressure gradient on the emplacement side thus venting radon and any other exposures away from workers, on the development side, and into the nuclear waste emplacement area. My concern is that these contaminants will be vented from the emplacement areas, with the heat from the thermal load, whichever scenario is utilized, via the exhaust ventilation into the air to drift with the winds. Any radiation leak, in any canister, would also be vented away reminiscent of the above ground bomb testing, at the Nevada Test Site, to affect the down-winders.

Response
Air from both the development and emplacement sides of the proposed repository would be exhausted from the repository to the atmosphere. The only radionuclides normally exhausted from the repository would be naturally occurring radon and radon decay products, as discussed in Section 4.1.2 of the EIS. The presence of these materials would be indistinguishable from natural background radiation in the environment around Yucca Mountain. Table 4-4 of the EIS shows that the potential dose to the maximally exposed individual during the year of highest exposure would be 1.3 millirem per year for expected conditions under the lower-temperature repository operating mode (the scenario which could result in the highest dose). Section 4.1.8 of the EIS discusses the potential for accidental radiation release from the repository, which would be very small. DOE expects no adverse radiation-related health effects to members of the public from either routine operations or hypothetical repository accidents.

7.5.7 (8916)
Comment - EIS001027 / 0002
I am concerned on behalf of those who will be put in harm's way as a result of DOE's proposed shipments, including both the public at large – that is, anyone who breathes the air, drinks or bathes in the water, or lives on the land in this region -- and also the workers involved with these shipments. This latter group includes the following:

- Workers at the nuclear power plants who have to remove the spent nuclear fuel from spent-fuel pools in order to put the spent nuclear fuel into casks. Even with the use remote equipment, these workers will be exposed to contaminated water in the pools and contaminated air in the buildings housing these pools.

- Truck drivers and railroad locomotive engineers who are in the vicinity of these casks during shipment and storage.

- Crews who monitor and maintain the vehicles that are used in these shipments.

- Workers at Yucca Mountain who unload casks and then empty shipping casks to put the spent fuel rods into disposal casks, during which time an known amount of radioactive gases and particulate matter is likely to be released. One reason for the likelihood of such releases is that the spent fuel rods that arrive at Yucca Mountain are all different. They have different histories, including their age, their years of use, the extent of their exposures to heat, water and radiation, and the condition of the welding of their metal tube cladding.

- Finally, the workers who move the disposal casks into the underground tunnels of Yucca Mountain both immediately and over the next 10,000 years will undoubtedly be exposed to radioactive emissions.

Response
Potential health impacts to the workers identified in the comment have been examined in the EIS, except the impacts to workers at the nuclear powerplants. These actions have been evaluated in separate National Environmental Policy Act documents prepared by the Nuclear Regulatory Commission as part of the licensing process for nuclear powerplants. The EIS considered the potential impacts to nuclear plant workers who would load the casks onto trucks or trains for transportation to Yucca Mountain, activities which are related to the repository and therefore within the scope of the EIS. However, occupational radiation exposure at Commission-licensed facilities is monitored and reported in strict accordance with regulations codified at 10 CFR Part 20.

Potential impacts to workers at the repository are discussed in Section 4.1.7 of the EIS while impacts to workers involved in the various aspects of transporting commercial spent nuclear fuel are discussed throughout the health and safety sections in Chapter 6. Workers at Yucca Mountain may be exposed during the period of construction, operation and monitoring, and closure, which could total up to more than 300 years. For purposes of analysis, individual workers were assumed to be occupationally exposed for up to 50 years. Transportation activities for the proposed action were estimated to last 24 years.

The main source of radiation exposure to workers is the penetrating electromagnetic external radiation (gamma rays), not radioactive emissions or contamination from the spent nuclear fuel assemblies. The potential for exposure to radioactive emissions or contamination is very low at Yucca Mountain. If the repository was approved for development, the approval of a license to operate would require strict compliance with occupational radiation protection standards similar to those at 10 CFR Part 20, thus ensuring the health and safety of the radiation workers at the repository.

7.5.7 (9211)
Comment - EIS000489 / 0005
The harshest thing I have to say today is that the Department of Energy just doesn't want to admit how deadly spent nuclear fuel is. I don't make a point about talking about this, but I was put on the spot by a citizen activist in my state, why don't you talk about how dangerous it is? Everyone who works on this knows. Let me try to.

How do we determine how dangerous spent nuclear fuel is? There are a number of different ways to approach this technically in the language of the health physics profession where we quote outputs from the origin to risk by computer codes. We'll try to speak plainly today.

DOE should have taken a conservative approach to radiological health by basing its evaluation on transportation of fuel that was only five or ten years out of the reactor. They choose, instead, 26-year-old fuel, which is considerably less dangerous. But even the fuel they have chosen is extremely dangerous.

My best example for you is one that I'm never comfortable using, but I think it's technically correct, and I think it should give us all a reason to pause and ask about why we have all the safety requirements, ask about why so many people die in the No Action alternative. It's because spent fuel is very dangerous.

Like this: In the time I've spoken already, if I had a spent nuclear fuel assembly here, to reference one from the EIS, I would have already gotten what in the business is known as an LD50 dose, a dose that gives either a cancer or radiation death to 50 percent of the exposed population. You have a lot of cesium and strontium that generates a gamma radiation field. There are other contributors to the dose as well.

If you were to stand next to, immediately next to the spent fuel assembly, which we believe has a surface dose rate of about 10,000 rem per hour – and we're trying to be conservative. We'll bottle it down to a 100 rem per minute exposure – how does your body react to that?

After a minute, mild symptoms of radiation sickness. After two minutes, vomiting, blood changes that wouldn't be immediately apparent, nor the doubling of the cancer risk.

After six minutes, you'd expect vomiting within three hours, hair loss, 50 percent probability of death in two months, and after 10 minutes or more, you'd be at the point where you'd expect an 80 to 90 percent probability of death within two months, and the survivors would have a hard time.

It's harsh to say these things. That's why it's important that the Department of Energy be challenged not to fall into the easy business of thinking that they have made this process of transporting waste safe.

I think the single greatest problem is what we used to call arrogance, and what social scientists now call, in highfalutin terms, the organizational atrophy of vigilance. We need to remind ourselves just how dangerous spent nuclear fuel is to make sure that whatever is done in its handling, storage, and disposal is done is recognition of just how dangerous the materials are.

Response
DOE is well aware of the high external radiation fields associated with commercial spent nuclear fuel and the potential for very serious and potentially deadly health effects from exposure to an unshielded fuel assembly. This is one reason the NWPA specifies isolation of this material in a deep geologic repository for thousands of years. However, with appropriate institutional controls an exposure to a member of the public or to nuclear facility workers due to an unshielded fuel assembly and high external radiation fields is not considered to be a credible scenario (an annual probability of less than 1 chance in 10 million).

DOE has reevaluated the fuel characteristics used for the base case accident analyses based on a hazard index approach as described in Section A.2.1.5. The revised fuel now used for the analyses in the Final EIS is younger than the fuel used in the Draft EIS. For example, the pressurized-water reactor fuel now used in the accident analyses ("representative" fuel) is 15 years old rather than 26 years old as assumed in the Draft EIS. DOE has also performed sensitivity analyses to determine the relationship between accident impacts and fuel characteristics. These studies indicate that the hottest fuel to be received at the repository (5 years old) would produce impacts about 3 times higher than the representative fuel selected for the analysis. It should also be noted that accidents involving transportation casks and waste packages would not involve only the hottest fuel since licensing limitations preclude loading these containers with only the hottest fuel.

7.5.7 (9518)
Comment - EIS001888 / 0179
[Summary of comments noted by Clark County Nuclear Waste Division staff at various citizens' meetings.]

Concerns over effects of the radiation in the area where it would be stored because of problems they observed when they lived in the Tri-Cities area near Hanford. Effects, on animals and plants, etc.

Response
DOE studied the potential impacts of radiation exposure to biota in the vicinity of the Yucca Mountain site and found the effects would be negligible. As discussed in Section 4.1.4.2, current international guidance is that chronic dose rates of 100 millirad-per-day or less are unlikely to harm even the more radiosensitive species. Potential doses to biota at Yucca Mountain would be well below these rates. A comprehensive environmental surveillance program has been established at the Hanford Site to monitor radiation effects on biota; however no radiation effects have been observed. Additional information is available in the Hanford Site Annual Environmental Report (DIRS 156931-DOE 2000).

7.5.7 (9921)
Comment - 010235 / 0001
The SDEIS evolving design puts workers at greater risk. The low temperature design increases worker's exposure to radioactive waste during the fuel blending and repackaging process, a procedure that has never been done before (p. 3-10). The effects of this prolonged exposure on workers, their offspring, and succeeding generations of offspring, are not documented.

Response
Selecting a lower-temperature operating mode could require that the repository be open longer, possibly up to 336 years (24 years of emplacement, 300 years of natural ventilation, and 12 years of closure activity), so the total number of workers involved with the work is increased, as noted in Section 3.1.7 of the Supplement to the Draft EIS (refer to Figure 2-9 in the Final EIS). Many of these additional workers would be radiation workers and exposed to radiation, so the overall worker population risk would be somewhat higher. However, the radiation dose to any individual radiation (involved) worker is estimated to be about the same as the thermal load scenarios, and to be lower for noninvolved workers, as shown in Section 4.1.7.5 of the Final EIS. The individual risk in all cases remains low, as discussed in Section 4.1.7 of the EIS. The potential impacts to workers for nonfatal cancers and to their succeeding generations from hereditary disorders would be even smaller, about 20 and 26 percent, respectively, of the fatal cancer risk. The potential for these effects is discussed in Section F.1.1. The Final EIS describes the potential risk of latent cancer fatality to workers in Section 4.1.7. The risk of the other nonfatal stochastic effects noted above can be estimated using the percentages presented, and is discussed in Section F.1.1 of the Final EIS.

7.5.7 (10372)
Comment - EIS001927 / 0012
One would be hard pressed to find in the DEIS many citations that refer to the dangers of irradiated fuel rods and high-level nuclear waste. Where is it described in there that just a few minutes exposure to fuel rods that have cooled down for years is still enough to cause a lethal exposure? Where is it mentioned that a lethal exposure to fuel rods just coming out of a reactor core after three years irradiation could occur in less than a minute? Where are the particular hazards of different radioactive poisons – alpha particles, beta particles, gamma rays, neutrons – described in simple enough terms that ordinary citizens can understand?

This DEIS retains that same "conspiracy of silence" about the health dangers of radioactivity that I encountered in the Yucca Mountain Project information center. But really, it's healthier for all of us to openly discuss that 800 pound gorilla sitting in the middle of the room.

Response
DOE is well aware of the high external radiation fields associated with commercial spent nuclear fuel and the potential for very serious and potentially deadly health effects from exposure to an unshielded fuel assembly. This is one reason the NWPA specifies isolation of this material in a deep geologic repository for thousands of years. However, with appropriate institutional controls an exposure to a member of the public or to nuclear facility workers due to an unshielded fuel assembly and high external radiation fields is not considered to be a credible scenario (an annual probability of less than 1 chance in 10 million).

DOE has reevaluated the fuel characteristics used for the base case accident analyses based on a hazard index approach as described in Section A.2.1.5. The revised fuel now used for the analyses in the Final EIS is younger than the fuel used in the Draft EIS. For example, the pressurized-water reactor fuel now used in the accident analyses ("representative" fuel) is 15 years old rather than 26 years old as assumed in the Draft EIS. DOE has also performed sensitivity analyses to determine the relationship between accident impacts and fuel characteristics. These studies indicate that the hottest fuel to be received at the repository (5 years old) would produce impacts about 3 times higher than the representative fuel selected for the analysis. It should also be noted that accidents involving transportation casks and waste packages would not involve only the hottest fuel since licensing limitations preclude loading these containers with only the hottest fuel.

Appendix A of the EIS reports the expected radionuclide inventory in curies for contributing radionuclides for both "average" fuel used to estimate total repository inventory and "representative" fuel used for transportation and repository preclosure accident analysis. Tables A-9, A-10, A-12, and A-13 list these values on a per assembly basis, and Table A-11 lists the total projected number of curies by isotope for the Proposed Action and the additional inventory modules. The EIS analysis did not require surface dose rates for irradiated fuel, so Appendix A does not provide them. For transportation impacts, the EIS conservatively uses the U.S. Department of Transportation surface dose rate limit for all transportation casks when calculating incident-free risk impacts to the public. In addition, none of the severe accidents evaluated in a recent Nuclear Regulatory Commission report (DIRS 152476-Sprung et al. 2000, Section 5.1.4) would result in a release of spent nuclear fuel assemblies from their shipping casks or a direct exposure to the public. For repository operations, DOE estimated personnel exposures for various activities from shielded elements based on the representative fuel assemblies during normal operations and postulated accidents. In summary, the EIS analysis included all appropriate information required to assess impacts from the spent nuclear fuel and high-level radioactive waste.

Section F.1 of the EIS contains a brief primer that includes discussion of the different types of radiation and potential human health effects. More detailed information is available in public libraries and on the Internet at web sites such as the Environmental Protection Agency's site (*http://www.epa.gov/radiation/*) and the Health Physics Society's site (*http://www.hps.org/publicinformation/*). DOE is committed to open discussions of the potential risks of radiation and of Yucca Mountain activities.

7.5.7 (10390)
Comment - EIS002192 / 0002
But what bothers me the most -- and I have stated it many times publicly -- is that the workers are allowed 5,000 millirems, and as the reports come out with Richardson stating that we have killed our people, this is very serious.

Response
Federal regulations (10 CFR Part 835) limit the current annual radiation dose to DOE workers to 5,000 millirem. DOE implements lower administrative limits (for example, 1,000 or 2,000 millirem per year at many facilities) as well as a philosophy of achieving the standards that are as low as reasonably achievable to help keep worker doses as far below the dose limits as possible. DOE is designing the proposed repository and surface facilities to keep worker radiation doses as low as reasonably achievable. In today's working environment at DOE facilities, very few workers come close to the 5,000-millirem-per-year limit.

7.5.7 (10395)
Comment - EIS002217 / 0001
Firstly what is radiation? No one in the DOE or the Nuclear Regulatory Agency -- either they don't know what it is or they know it is and they won't say, and this I feel should be brought up.

Nuclear radiation is basically alpha, beta, gamma and delta waves accompanied by electromagnetic waves, as well.

All of these waves are negative energy. They are in a distorted condition. Their affect on the human mind and human existence is awesome. This issue has not been addressed.

Now, alpha, beta and gamma and delta waves are mental energy waves. They are the same waves that constitute our minds.

Brain waves are lower harmonics of these waves, so out from this refined uranium and other radioactive elements come -- comes a flood of distorted mental energy waves creating a distortion in our minds.

This is why radiation is bad, why we're seeing the intellectual collapse of many American citizens.

This issue, as I say, has not been addressed and the public should be made aware of this basic fact before we talk about what we're going to do with radioactive waste in -- in a populated area.

Now in addition to these negative mental energy waves that come out from radioactive elements, refined uranium and so forth, we have negative electromagnetic waves, energy waves in an extremely distorted and anti-life condition.

In effect, negative life energy, negative electronic energy, negative magnetic energy, and these are also affecting the human aura tremendously, and this is not being addressed by the scientists of these agencies.
Now, if this level of understanding isn't even attained by officials of the DOE, what about higher levels of understanding about what we're doing?

Response
Thank you for your comment. DOE is unaware of any peer-reviewed scientific literature that supports the opinions expressed by this commenter. Appendix F of the EIS contains a primer on the types of ionizing radiation and exposure pathways important to the impact evaluations.

7.5.7 (10396)
Comment - EIS002217 / 0002
The fact, like it or not, the earth is a living being with energy flows and energy centers that are scientific facts.

If the reality of nuclear fallout is not understood by members of government agencies, and obviously the next level of understanding is not understood what these elements do to the planet when we place them in certain areas that we could define as sacred areas.

Now that might sound mystical, not scientific, but when we talk about sacred areas in a scientific sense, we're talking about places such as Yucca Mountain where the planet interphases with the energy fields of the universe and where -- where certain kinds of energies come into earth in order to revitalize us.

If we place radioactive elements, a tremendous source of awesome negative energy in the sites we're in effect doing a horrible damage to the planet and committing harmful acts to all of humanity, and I feel these issues should be addressed, and since other people know more about the Yucca Mountain matter in particular.

Response
Thank you for your comment. DOE is unaware of any peer-reviewed scientific literature that supports the opinions expressed in this comment.

7.5.7 (10495)
Comment - 010115 / 0003
These designs increase worker exposure to radioactivity and further challenges their health. We know that a potential for fatality from cancer increases the longer you're around radiation. And a low-level facility increases the number of workers and the amount of time they're exposed to radiation leaks. So the question isn't directly addressed of how many people will develop cancer potentially and how many people will be exposed, how this will affect larger populations, their relatives, their children for generations to come.

So the SDEIS did not detail the long-term cumulative health impact of workers and civilians.

Response
The potential cumulative health impact to members of the public and workers over the project duration prior to closure are presented in the Supplement to the Draft EIS, where these impacts are also compared to the health impacts estimated for the Draft EIS. Potentially exposed individuals and populations would be the same as those described in the Draft EIS, namely the maximally exposed individual member of the public and worker, general population within 80 kilometers of the repository, and the exposed repository workforce. The text of Section 3.1.2.1 of the Supplement to the Draft EIS describes the estimates of latent cancer fatalities to the public from exposure to radiation from the flexible design operating modes. Section 3.1.7 of the Supplement describes the estimates of fatalities from industrial hazards and latent cancer fatalities from radiation exposure under the flexible design. In general, the lower-temperature repository operating mode would result in higher potential impacts to members of the public and workers than the thermal load scenarios because of the longer duration of the project. Overall, the exposures to individual members of the public and individual workers are not higher, as shown in section 4.1.7.5 of the Final EIS. The Final EIS fully describes the potential human health impacts of the flexible design operating modes in Section 4.1.7 for all project phases and in Section 4.1.7.5 for total project impacts.

DOE believes that adverse health impacts resulting from the Proposed Action are highly unlikely. For, example, in the vicinity of the repository (the area within 50 miles), DOE estimates short-term impacts from construction, operation and monitoring, and closure of the proposed repository would result in less than 1.3 millirem per year to the maximally exposed member of the public (see Table 4-35 of the EIS). This exposure is less than 15 percent of the 15-millirem limit promulgated at 40 CFR 197.4 and 10 CFR 63.204 and less than 1 percent of the annual 200-millirem dose to members of the public in Amargosa Valley from background levels of naturally occurring radon-222 and its decay products. Also, for the updated flexible design, for the first 10,000 years after repository closure, the mean peak annual receptor dose to the reasonably maximally exposed individual would be more than 100,000 times less than the individual protection standards at 40 CFR 197.20 and 10 CFR 63.311, which allow up to 15-millirem-per-year dose rates during the first 10,000 years (see Table 5-6). The peaks would be even smaller at greater distances.

The EIS also provides estimates of lifetime doses and additional fatal cancers for entire populations that could be affected by the Proposed Action. For example, DOE estimates that for the lower-temperature operating mode, the potentially affected population within 80 kilometers (50 miles) of the repository (estimated to be 76,000 individuals in 2035), could receive as much as 4,000 person rem over 341 years of operation that could result in as many as 2 additional cancer fatalities in the exposed population. This would represent an increase of 0.002 percent of the 89,000 cancer deaths expected to occur from natural causes in the potentially exposed populations over a 340-year period (that is, five 70-year generations). In all cases, these risks have been shown to be very low and, considering the conservatisms used in these estimates, likely nonexistent. As such, DOE believes that even if large-scale health studies were conducted, the identification of adverse health impacts resulting from the Proposed Action would not be discernible.

7.5.7 (10501)
Comment - EIS002138 / 0008
Volume 2, page[s] 1[I]-9 through 1[I]-12, what is the conclusion of impact on the nuclides on public health posed in the repository and during transportation to the site?

Response
The referenced section of the Draft EIS describes the radioactive material inventories consisting of both DOE and commercial spent nuclear fuel and high-level radioactive waste. The results of the analysis in the Draft EIS show that the mean peak dose rate would be 0.22 millirem per year, with a 0.000011 probability of a latent cancer fatality at the repository location as described in Section 5.4 of the Draft EIS (Table 5-4). There would be an even lower probability of other radiation-related health effects. Iodine-129 and technetium-99 would be the major dose contributors.

The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197.

Chapter 6 of the Final EIS discusses potential health impacts of the transportation of spent nuclear fuel and high-level radioactive waste, with supporting information in Appendix J. DOE estimates three latent cancer fatalities could occur nationally as a consequence of transporting spent nuclear fuel using mostly legal-weight trucks and one latent cancer fatalities could occur from using mostly rail over the 24 years of the Proposed Action. These estimates are based on a large number of people each receiving a small radiation dose and assuming there is a risk of health effect without threshold (the linear no-threshold hypothesis). The dose and risk to individuals would be very small. For example, Section 6.2.3.1 of the EIS discusses that the maximally exposed resident along a legal-weight truck route would receive about 6 millirem over 24 years of transport, with a 0.000003 risk of latent cancer fatality (about 1 chance in 300,000). A small number of individuals (for example, a service station attendant where trucks stopped) could receive larger doses. Section J.1.3.2 describes the methods and assumptions DOE used to estimate such impacts.

Although low levels of radiation exposure are estimated to result from the proposed action to construct, operate and monitor, and close the proposed geologic repository and the EIS provides estimates of latent cancer fatalities that could result from these small doses, these estimates are provided primarily to inform the decisionmaking process by enabling a quantitative comparison of impacts between the alternatives evaluated in this EIS. In all cases, estimates of latent cancer fatalities resulting from very small doses summarized in the EIS should be viewed as conservatively high; in fact, the uncertainties and conservatisms associated with these estimates (see Appendix K, Section K.4.3.2 and Appendix F, Section F.1.1.5) are such that DOE believes that any adverse health impacts resulting from these exposures would be highly unlikely or nonexistent.

7.5.7 (10722)
Comment - EIS000112 / 0002
There are two more examples that I wanted to bring up of the technical problems that are associated with this project.

And one of them is right here, right outside the door here is a dust detector, and it's supposed to be able to detect radiation in the dust.

Well, UNLV [University of Nevada, Las Vegas] finally informed us the other day that the dust worldwide has half a picocurie of plutonium per gram. That's not anything too serious. The EPA [Environmental Protection Agency] requires five times that amount to be remediated immediately.

This dust detector out here has never detected anything according to the guy that runs it, so it's not detecting what's here to begin with.

The other thing that UNLV pointed out is that the dust in Plutonium Valley, which is disappearing by the way, going up into the air contains 500 picocuries per gram, so the Test Site is in violation of EPA laws by not remediating that.

So when the wind blows from that area to here, this dust detector has never detected that, either, so we have this stuff inundated on us. We know that now from the UNLV studies, and we have a detector out here that says that it isn't happening.

That's typical of the technical problems with these kind of projects.

Response
DOE routinely monitors levels of plutonium on the Nevada Test Site and reports the results of this monitoring in the annual site environmental report. The report for 1997 states that the highest detected level of plutonium onsite was less than 0.00000000008 picocuries per liter of air (DIRS 146591-Black and Townsend 1996). The level of plutonium from this source in offsite air would be much smaller, due to redeposition on the ground and atmospheric dispersion.

7.5.7 (10749)
Comment - EIS001886 / 0005
The DOE's analysis that the primary radiological impacts would occur from the water pathway is not correct for collective population doses. The EPA [Environmental Protection Agency] Science Advisory Board report on carbon-14 emissions from Yucca Mountain showed that, while the individual doses from carbon-14 emissions would be tiny, the collective global doses would be immense. Based on the linear no-threshold hypothesis, which is the basis for current radiation protection standards, and which is also the modeling approach recommended in the BEIR V committee report,[3] carbon-14 collective doses would be estimated to cause thousands of cancer fatalities.[4] These estimates cannot be ignored in the Draft EIS.

[3]National Research Council, Commission on Life Sciences, Board on Radiation Effects Research, Committee on the Biological Effects of Ionizing Radiations, *Health Effects of Exposure to Low Levels of Ionizing Radiation: BEIR V*. Washington, D.C.: National Academy Press, 1990.

[4]*United States Environmental Protection Agency, Science Advisory Board, An SAB Report: Review of Gaseous Release of Carbon-14: Review, by the Radiation Advisory Committee, of the Release of Carbon-14 in Gaseous Form from High-Level Waste Disposal,* EPA-SAB-RAC-93-010. Washington, DC, April 1993.

Response
The EIS did not report potential global impacts to environmental "commons" such as surface waters because, in the case of Yucca Mountain, there would be no release of radioactive material to major rivers, and thus no releases to the oceans. As stated in *Technical Bases for Yucca Mountain Standards*, " … the most likely pathway for global distribution are gaseous releases of carbon dioxide containing the radioactive isotope of carbon-14, that eventually will escape from the waste containers, or by widespread distribution of foodstuffs grown with contaminated water" (DIRS 100018-National Research Council 1995). However, the National Research Council stated that "In general, the risks of radiation produced by such wide dispersion are likely to be several orders of magnitude below those to a critical group" (DIRS 100018-National Research Council 1995). For example, the report estimated that the average dose to members of the global population, based upon the release of 91,000 curies of carbon-14, to be 0.003 microsieverts per year (0.0003 millirem per year) and equated that to an annual risk of fatal cancer of 1.5 in 10 billion (1.5×10^{-10}). For comparison, the individual dose standard set by the Environmental Protection Agency in 40 CFR Part 197 of 1.5×10^{-4} sieverts per year (15 millirem per year) for the maximally exposed individual; a factor of 50,000 times higher (DIRS 100018-National Research Council 1995).

The report states (DIRS 100018-National Research Council 1995), " … the 'linear hypothesis' implies that even very small increments to background doses might cause effects from cancer induction in the same ratio (5×10^{-4}) as larger doses. Using the linear hypothesis to calculate the effects of very low doses on large populations requires multiplying this factor by cumulative dose imposed on populations numbered in the trillions over the life of the repository.

"There are, however, important cautions to be noted with this procedure. With respect to small increments to natural background radiation levels, the BEIR V report (DIRS 100473-NRC 1990) states that:

> 'Finally, it must be recognized that derivation of risk estimates for low doses and dose rates through the use of any type of risk model involves assumptions that remain to be validated. At low doses, a model-dependent interpolation is involved between the spontaneous incidence and the incidence at the lowest doses for which data are available. Since the committee's preferred risk models are a linear function of dose, little uncertainty should be introduced on this account, but departure from linearity cannot be excluded at low doses below the range of observation. Such departures could be in the direction or either an increased or decreased risk. Moreover, epidemiologic data cannot rigorously exclude the existence of a threshold in the millisievert dose range. Thus the possibility that there may be no risks from exposures comparable to external natural background radiation cannot be ruled out. At such low doses and dose rates, it must be acknowledged that the lower limit of the range of uncertainty in the risk estimates extends to zero' [Appendixes F and K of the EIS provide further details related to uncertainties resulting from use of the linear no-threshold hypothesis to predict health effects from exposure to low-level radiation.]
>
> "… Therefore, there is great uncertainty about the number of health effects that would be imposed on the global populations because of the difficulties in interpreting the risks associated with such small incremental risks from carbon-14 releases at Yucca Mountain."

Because of these large uncertainties, DOE considers estimates of global health effects to be highly speculative and therefore did not estimate global collective doses or health effects in the EIS. However, the Department agrees with the Environmental Protection Agency (64 *FR* 46976, August 27, 1999) and the National Commission on Radiation Protection (DIRS 101858-NCRP 1995) that, for purposes of optimizing protectiveness of design alternatives, estimation of population doses is merited. However, DOE believes that information important to design optimization can be obtained by estimating collective dose to the regional populations within 84 kilometers [50 miles] of the repository, thereby precluding the need to perform the more speculative, global dose health risk calculations. For these reasons, the EIS evaluated in detail potential radiological exposures to the maximally exposed individual and regional populations (within 84 kilometers [50 miles]) from both groundwater and atmospheric pathways. Results of these evaluations are presented in Sections 5.4 and 5.5 for waterborne and atmospheric releases, respectively.

7.5.7 (10814)
Comment - EIS000280 / 0008
The combination of engineered and natural barriers will ensure that the Yucca Mountain repository will protect the public health and safety and the environment for thousands of years.

Response
Thank you for your comment. Protection of the environment and public health and safety is the objective of DOE efforts for the proposed Yucca Mountain Repository.

7.5.7 (10816)
Comment - EIS000280 / 0009
Potential long-term releases of radiation from the repository are well within the proposed limits set by the Environmental Protection and the Nuclear Regulatory Commission.

Response
The analysis of the environmental consequences of long-term repository performance considered the release of radiological constituents via the groundwater pathway and atmospheric radiological emissions as discussed in Sections 5.4 and 5.5 of the EIS. As noted by the commenter, the estimated radionuclide releases would be within the limits set by both the Environmental Protection Agency and Nuclear Regulatory Commission for the proposed geologic repository.

7.5.7 (10873)

Comment - 010364 / 0008

And finally, must YMP [Yucca Mountain Project] employ the best available science? Both the President in a letter to Governor Guinn, State of Nevada; and the Honorable [Secretary] of Energy Mr. Spencer [Abraham] they have called to use the best scientific methods for investigation of YMP as a repository. However, it is apparent that YMP management is continuing to ignore the call for use [of] the best scientific methods for investigation of human health risk for complex mixtures.

Response

The impact of interest to the long-term assessment of potential human health effects from the Proposed Action is the induction of latent cancer fatalities. For potential cancer induction at low dose rates, the dose conversion factors and risk coefficients used for the EIS analysis (Section F.1.1.5 of the EIS) are consistent with recommendations by the National Council on Radiation Protection (DIRS 101882- and 101883-NCRP 1996) and the International Commission on Radiological Protection (DIRS 101075-ICRP 1977), and assume additive cell responses from mixed radiation. Although synergistic responses from mixed radiation (that is, where the combined effects are greater than the additive response) have been postulated, this is of research interest only at this time. Since the purpose of the EIS and of all National Environmental Policy Act evaluations is to provide information to decisionmakers, DOE believes it is not appropriate to use research models that include potential synergistic effects from mixed irradiation. However, the Department continues to monitor these research activities and any future recommendations by the scientific advisory groups that might contain such considerations.

Physiologically Based Pharmacokinetic (PBPK)-based internal dosimetry models recommended by the National Council on Radiation Protection (DIRS 101882- and 101883-NCRP 1996) and the International Commission on Radiological Protection (DIRS 101075-ICRP 1977) have been used in this EIS to estimate potential radiation dose. Although the use of PBPK models could be expanded to consider impacts from all chemical forms, the resulting effects from exposure to both radionuclides and heavy metals estimated for the EIS are quite small (see Chapter 5 for details). Thus, it is unlikely that the use of alternative models would increase the estimated effects or add meaningful information to the decisionmaking process.

Although there is literature regarding complex interactions between metals and radionuclides, it is largely research information that is not currently contained in consensus modeling. The models used in this EIS could be expanded to consider impacts from all chemical forms; however, the effects from exposure to both radionuclides and heavy metals estimated for the EIS would be quite small. Thus, it is unlikely that the use of alternative models would increase the estimated effects or add meaningful information to the decisionmaking process.

7.5.7 (10897)

Comment - EIS000447 / 0005

There would be little harm posed to radiation, less than one percent an average American receives from natural resources would be from Yucca Mountain. To think it is one percent we have from the background and we are not willing to take this risk is absolutely ridiculous.

Response

Thank you for your comment. DOE recognizes that the risk of cancer and other health effects caused by exposure to ionizing radiation is of concern to many citizens. Thus, in addition to keeping radiation doses within Environmental Protection Agency standards (40 CFR Part 197) and Nuclear Regulatory Commission licensing criteria (10 CFR Part 63), DOE is also committed to keeping radiation doses from Yucca Mountain-related preclosure activities to levels that are as low as is reasonably achievable. For example, in the vicinity of the repository (the area within 50 miles), DOE estimates short-term impacts from construction, operation and monitoring, and closure of the proposed repository would result in less than 1.3 millirem per year to the maximally exposed member of the public (see Table 4-35 of the EIS). This exposure is less than 15 percent of the 15-millirem limit promulgated at 40 CFR 197.4 and 10 CFR 63.204 and less than 1 percent of the annual 200-millirem dose to members of the public in Amargosa Valley from background levels of naturally occurring radon-222 and its decay products. For the flexible design, for the first 10,000 years after repository closure, the mean peak annual receptor dose to the reasonably maximally exposed individual would be more than 100,000 times less than the individual protection standards at 40 CFR 197.20 and

10 CFR 63.311, which allow up to 15-millirem-per-year dose rates during the first 10,000 years (see Table 5-6). The peaks would be even smaller at greater distances.

7.5.7 (10912)
Comment - EIS000379 / 0003
When we talk about ionizing radiation, it's something that just about cannot be mitigated. The effects of ionizing radiation have been well documented from as far back as Hiroshima, Nagasaki, up to more recently Chernobyl, and even in this country Three Mile Island, and some of these things are too recent for us to have the data yet to know how to evaluate them. These cancers have now had time to incubate, and we really don't know what the effects are.

Response
The potential for exposure to ionizing radiation can be mitigated. For example, time, distance, and shielding are three common ways used to mitigate and reduce the potential for radiation exposure. The effects of high doses of radiation exposure may also be mitigated, although this mitigation consists of medical intervention since the exposure has already occurred.

Health effects of radiation exposure can be placed in two categories: stochastic (random) and nonstochastic (deterministic). Stochastic effects are those that have a probability (not a certainty) of occurrence and include somatic effects such as latent fatal and nonfatal cancers, and genetic effects such as hereditary disorders that may occur in the progeny of exposed individuals (that is, future generations). The probability of the occurrence of these effects, not their severity, is affected by the amount of radiation exposure an individual receives. For the estimation of the probability of occurrence of these effects, DOE used the linear no-threshold hypothesis, which conservatively assumes that there is no level of radiation exposure below which stochastic health effects (cancer induction) could occur.

On the other hand, nonstochastic or deterministic effects are predicted to occur only after a certain amount of radiation exposure has occurred. These occurrence and severity of these effects (not probability of occurrence) are affected by the amount of radiation exposure an individual receives and include somatic effects such as cataracts, premature aging, infertility, emphysema and pulmonary fibrosis as well as teratogenic effects in children exposed in-utero such as microcephaly (smallness of the head) and mental retardation. Most of the health effects noted by the commenters are nonstochastic effects and would not be expected to occur even at doses thousands of times higher than those resulting from the Proposed Action.

DOE recognizes that the risk of cancer and other health effects caused by exposure to ionizing radiation is of concern to many citizens. Thus, in addition to keeping radiation doses within Environmental Protection Agency environmental protection standards (40 CFR Part 197) and Nuclear Regulatory Commission licensing criteria (10 CFR Part 63), DOE is also committed to keeping radiation doses from Yucca Mountain-related preclosure activities to levels that are as low as is reasonably achievable. For example, in the vicinity of the repository (the area within 50 miles), DOE estimates short-term impacts from construction, operation and monitoring, and closure of the proposed repository would result in less than 1.3 millirem per year to the maximally exposed member of the public (see Table 4-35 of the EIS). This exposure is less than 15 percent of the 15-millirem limit promulgated at 40 CFR 197.4 and 10 CFR 63.204) and less than 1 percent of the annual 200-millirem dose to members of the public in Amargosa Valley from background levels of naturally occurring radon-222 and its decay products. For the flexible design, for the first 10,000 years after repository closure, the mean peak annual receptor dose to the reasonably maximally exposed individual would be more than 100,000 times less than the individual protection standards at (40 CFR 197.20 and 10 CFR 63.311, which allow up to 15-millirem-per-year dose rates during the first 10,000 years (see Table 5-6). The peaks would be even smaller at greater distances.

The EIS also provides estimates of lifetime doses and additional fatal cancers for entire populations that could be affected by the Proposed Action. For example, DOE estimates that for the lower-temperature operating mode, the potentially affected population within 80-kilometers (50 miles) of the repository (estimated to be 76,000 individuals in 2035), could receive as much as 4,000 person-rem over 341 years of operation that could result in as many as 2 additional cancer fatalities in the exposed population. This would represent an increase of 0.002 percent of the 89,000 cancer deaths expected to occur from natural causes in the potentially exposed populations over a 340 year period (that is, five 70-year generations). This would represent an increase of 0.002 percent of the 89,000 cancer deaths expected to occur from natural causes in the potentially exposed populations over a 340 year period. Similar estimates have been made for impacts to populations exposed over 10,000 years (see Table 5-7).

Although low levels of radiation exposure are estimated to result from the proposed action to construct, operate and monitor, and close the proposed geologic repository and the EIS provides estimates of latent cancer fatalities that could result from these small doses, these estimates are provided primarily to inform the decisionmaking process by enabling a quantitative comparison of impacts between the alternatives evaluated in this EIS. In all cases, estimates of latent cancer fatalities resulting from very small doses summarized in the EIS should be viewed as conservatively high; in fact, the uncertainties and conservatisms associated with these estimates (see Sections K.4.3.2 and F.1.1.5) are such that DOE believes that any adverse health impacts resulting from these exposures would be highly unlikely or nonexistent.

7.5.7 (11049)
Comment - EIS000610 / 0013
Page 2-84 [3-84], Section 3.1.8.3. The discussion focuses on workers in a tunnel. There is no mention of workers who are not in the tunnel but will be exposed to the dust from the material removed from the drilling. What is the impact of strong winds moving the material to the public?

DOE's position is they will, quote, "use the experience gained during environmental studies facility [Exploratory Studies Facility] activities to design engineering controls to minimize future exposures."

What does that statement mean? How many will have a reduced quality of life, and how many will die? Are these people working for a company who will come under SIIS? That will cost the people of Nevada more money.

Response
Chapter 3 of the EIS describes the affected environment in the vicinity of Yucca Mountain to establish a baseline against which DOE can measure potential environmental impacts. Section 3.1 of the EIS describes the environmental conditions that will exist at and in the region of the proposed repository site at Yucca Mountain after the conclusion of site characterization activities. The potential impacts of these activities are described in Chapter 4 of the EIS. Section 4.1.2 of the EIS describes possible nonradiological and radiological impacts to air quality from preconstruction testing and performance confirmation, construction, operation and monitoring, and closure. Section 4.1.7 of the EIS describes the short-term (prior to completion of repository closure) health and safety impacts to workers (occupational impacts) and to members of the public from these same activities. DOE would use the engineering and practical experience gained during excavations in the Exploratory Studies Facility to ensure that exposures to workers during repository operations would be within regulatory limits and as low as reasonably achievable. Sections 4.1.2 and G.1 of the EIS evaluate surface exposures from excavated material to workers and the public. Overall, worker and public exposure to excavated material would be small fractions of regulatory limits. No deaths nor reduction in quality of life would be expected among workers or members of the public from these exposures.

NOTE: The quote noted by the commenter was incorrect in the Draft EIS and will be changed in the Final EIS to say, "use of the experience gained during exploratory..."

7.5.7 (11113)
Comment - EIS001207 / 0002
Have previous DOE Yucca Mountain Site calculations included radiation doses to the environment and surrounding population from 17 metric tons of nuclear weapons excess plutonium in cans placed in canisters filled with borosilicate glass containing intensely radioactive high-level waste? What adjustment's have been made by DOE Yucca Mountain Site Office to radiation dose(s) to a MEI [maximally exposed individual] and, thereby, health risks to the residents in vicinity of the Yucca Mountain Repository? The MEI is "assumed" to be the off-site person receiving the highest exposure at point of maximum contaminates 24 hours a day, 7 days a week, for the period of operations under analysis. Which "operational" standard is DOE applying to the Yucca Mountain HLRW [high-level radioactive waste] Disposal Site: the period of time HLRW is transported and placed in the site, 100 years, and/or 10,000 years, or the period of time when the HLRW has decayed to only half its radioactivity (100,000's of thousand years)? Has DOE included genetic impacts in MEI dose calculations, with and without 50 metric tons of can-in-canister and MOX [mixed-oxide] fuel recycled plutonium?

Response

DOE calculations of the potential human health impacts of immobilized plutonium or mixed-oxide fuel in the proposed Yucca Mountain Repository were not included in DOE studies prior to the Draft EIS. The *Yucca Mountain Science and Engineering Report* (DIRS 153849-DOE 2001) and the EIS include estimates of impacts from these materials. The EIS includes analysis of these materials for the operational period, for 10,000 years following repository closure, and for the calculation of peak dose beyond 10,000 years. However, for preclosure operations the inclusion of these materials makes no difference in impact calculations. The immobilized plutonium is contained within high-level radioactive waste canisters that would not be opened at Yucca Mountain. The mixed-oxide spent nuclear fuel is similarly contained in the fuel assemblies that would be transferred intact to disposal canisters. Operational impact estimates are presented in Section 4.1.7 of the EIS. Because of the projected limited quantity of these materials compared to the other spent nuclear fuel and high-level radioactive waste inventories, the inclusion of these materials does not significantly affect postclosure performance. Section 5.4 presents postclosure impact estimates.

The Nuclear Regulatory Commission defines operational standards in 10 CFR 63.111 for the period through permanent closure. The standard states, "During normal operations, and for Category 1 design basis events, the annual dose to any real member of the public, located beyond the boundary of the site shall not exceed a TEDE [total effective dose equivalent] of 0.25 mSv [millisieverts] (25 millirem) [10 CFR 63.111(a)(2)]." The postclosure performance standard set by the Environmental Protection Agency at 40 CFR 197.20 specifies an annual committed effective dose equivalent of 15 millirem to the reasonably maximally exposed individual from releases from the undisturbed Yucca Mountain disposal system as the standard for 10,000 years following disposal. The reasonably maximally exposed individual is defined in 40 CFR Part 197.21 as a hypothetical person who lives approximately 18 kilometers (11 miles) from the repository, has a diet and lifestyle representative of current residents of Amargosa Valley, Nevada, and drinks 2 liters [0.5 gallon] of water per day from wells drilled into the groundwater.

The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197, thus, DOE believes health impacts of any kind would be highly unlikely.

The potential for hereditary effects from exposure to ionizing radiation is discussed in Section F.1.1.5 of the EIS. It is about one-fourth of the potential risk of latent cancer fatality, so elsewhere in the EIS DOE has chosen to present only the latent cancer fatality estimates.

7.5.7 (11196)

Comment - EIS002108 / 0001

I want to comment briefly on a comment that was made by an earlier speaker. I want to assure all of the men in this room and maybe in Las Vegas and in the whole country that they will not be sterile in the next twenty years by anything that has to do with nuclear power or Yucca Mountain or activities associated with those. Jockey shorts I think are the cause that people mostly cite.

Now, you know, I apologize for sort of making light of a serious subject and I know that the speaker's intentions were serious, but what I want to do is use that to illustrate the face that we should be not making decisions based on rhetoric, but we should be making decisions based on facts and experience and good science, and I've been sitting in this hearing room all day and I've heard, you know, a significant amount of rhetoric and I've heard not a lot of science in defense of that rhetoric. So I would just encourage us to kind of get back on that even keel, and to that extent, I want to talk about the facts that surround transportation safety.

Response

Thank you for your comment.

7.5.7 (11265)
Comment - 010008 / 0007
Spills will occur as will incidents at the storage facility. What will be the impact of these likely occurrences only an hour and a half away from a healthy population?

Response
Before beginning repository operations, DOE must have systems in place to prevent and mitigate spills. Because the spent nuclear fuel and high-level radioactive waste would be solid material, the potential for spills would be very small, mainly from liquids and fluids such as those used in any industrial operation.

The following sections of the EIS discuss the measures and plans DOE would use to protect onsite and offsite areas from spills or accidents at the repository site:

- Section 4.1.3.1 discusses the approaches DOE would follow during preconstruction testing and performance confirmation activities to minimize the effects on groundwater of potential releases of hazardous materials.

- Sections 4.1.3.2 and 4.1.3.3 contain discussions on potential contaminant spread to surface water and groundwater, respectively. The discussions include hazardous liquid materials that DOE would store or use on the site, the potential for release of the materials as a result of a spill, and the measures that DOE would institute to prevent their spread during construction, operation and monitoring, and closure.

- Section 4.1.4.4 contains a discussion on contamination that describes how DOE would clean up and dispose of soils contaminated by radiological or nonradiological hazardous materials.

- Section 4.1.8.1 discusses onsite radiological accidents. It notes that impact calculations show that the quantities of radioactivity released to the environment and the quantities of material deposited on the ground would be very low and below the Environmental Protection Agency Protective Action Guidelines, so interdiction would not be necessary.

- Section 4.1.8.2 discusses the control of releases of nonradiological hazardous materials in the event of an accident.

- Sections 9.3.3.1 and 9.3.3.2 discuss the mitigative measures that DOE would institute in the event of an onsite spill or accident to minimize the spread of the released contaminant (radiological and nonradiological) to or by surface water and groundwater, respectively.

7.5.7 (11345)
Comment - EIS002268 / 0006
The department must release all radiation health studies heretofore classified as secret so that good science can replace expedient science, to establish epidemiological studies for those nuclear workers not yet studied.

Response
DOE is unaware of any radiation health studies that remain classified. The Department has developed the Comprehensive Epidemiologic Data Resource Program to provide public access to health and exposure data concerning DOE installations. Most of the data are from epidemiologic studies conducted by DOE-funded researchers as part of the Worker Health and Mortality Study. In addition, the Comprehensive Epidemiologic Data Resource Program includes studies of populations residing near DOE installations and other studies of radiation health effects, such as classic studies of atomic bomb survivors and radium dial painters. This information is available on the Internet at http://cedr.llbl.gov/ or by contacting the DOE Office of Epidemiologic Studies in Germantown, Maryland.

7.5.7 (11413)

Comment - EIS002251 / 0011

So anyway with the DOE record of having admitted now that there are past cancers associated with the nuclear industry and with the Nevada Test Site, and they are willing to pay for some of the health effects, I think that to say that we have these few amounts of incidences and increasing of cancer is just totally ignorance.

Response

DOE is well aware of the potentially harmful effects of exposure to radiation. In addition, DOE recognizes that the risk of cancer, particularly the risk of cancer caused by ionizing radiation, is of concern to many citizens. DOE is committed to keeping radiation doses from Yucca Mountain-related preclosure activities below the regulatory radiation exposure limits and also to levels that are as far below these limits as is reasonably achievable. Some low levels of radiation exposure may occur from Yucca Mountain activities. DOE believes that it is very important that the risk of these exposures be evaluated using scientific evidence presented by the National Academy of Sciences, National Council on Radiation Protection and Measurements, and the International Commission on Radiological Protection. The current estimate of the risk of a latent cancer fatality from ionizing radiation is 0.0005 per rem received by an exposed population (0.0004 per rem received by an exposed worker population). In the vicinity of the repository (within 50 miles) DOE estimates that no individual would receive more than a few millirem (a thousandth of a rem) per year during operations (see Section 4.1.7 of the EIS). For the first 10,000 years after repository closure, the mean peak annual receptor dose to the reasonably maximally exposed individual would be more than 100,000 times less than the Environmental Protection Agency individual protection standard (40 CFR 197.20), which allows up to 15-millirem-per-year dose rates during the first 10,000 years (see Table 5-6). In addition to the 10,000-year compliance period, DOE has evaluated potential impacts for the period of geologic stability at the repository (that is, 1 million years). These results show a mean peak dose rate that would be much lower than background levels (see Table 5-8 for details). For these levels of exposure, DOE believes that adverse health effects would be unlikely to occur.

7.5.7 (11753)

Comment - 010075 / 0001

Radon data fluctuations in Figures 3 and 4 in reference CRWMS M&O 2000d "Ventilation System Radon Review" indicate that the proposed repository host rocks are highly permeable. In evaluating the potential future doses from radionuclide transport, has this high permeability been used? And what is the rock permeability associated with these radon readings.

Response

Figures 3 and 4 of the *Ventilation System Radon Review* (DIRS 150246-CRWMS M&O 2000) show the correlation of hourly measured barometric pressure with hourly radon concentration measurements and hourly radon flux estimates in the Exploratory Studies Facility, which would form a portion of the repository main access drifts. These figures show that radon concentration and radon flux in the Exploratory Studies Facility are dependent upon the barometric pressure, showing the permeability of the host rock. Therefore, the permeability of the host rock is reflected in every estimate of radon concentration and radon flux shown, which were used to develop concentration and flux values used in the EIS. Estimates of rock permeability are not presented directly in the EIS because estimates of radon flux and radon concentration are more useful for estimating dose from radon and human health impacts.

7.5.7 (11842)

Comment - EIS001736 / 0007

I assume that those members of Congress who approved the first Nuclear Waste Policy Act in 1982 believed what their generous electric utility contributors had told them, that radioactive waste is just a political problem, not a technical one, and that the waste could be safely transported on our roads and rails and that a safe, permanent disposal location could be found. They maybe even were told that only a few latent cancer deaths would result. The electric utility lobbyists maybe even believed all that, but many people had challenged those claims long before Congress voted, and far more know today that radioactive waste is, of course, a political problem, a not-in-my-backyard or not-on-my highway problem; but that it is also a technical problem.

It was back in 1977 when I first learned about tritium, or radioactive hydrogen, and about how much tritium Union Electric was estimating it would create here in Missouri at the Callaway Plant. I read that Union Electric and the

U.S. Nuclear Regulatory Commission expected that the Callaway plant could quite possibly generate and release thousands of curies of tritium into the environment every year, into the air and the Missouri River through pipes and vents as a part of the routine operation of the plant. It would not take an accident. So I phoned a health physicist at Oak Ridge National Laboratory in Tennessee and asked him to tell me about tritium. He answered, "Tritium is no big deal, all it can do is destroy a DNA molecule." That was back in 1977 when construction of the Callaway plant had barely begun.

Response
Thank you for your participation in the Yucca Mountain EIS process.

7.5.7 (12073)
Comment - EIS002311 / 0002
The DEIS's conversion of the reference dose for uranium to a threshold concentration (in section 5.6.3) is arguably incorrect because the conversion factor is based upon a 153 pound person, disregarding the lower body weights of the more susceptible population of children.

Response
The use of a 70-kilogram (150-pound) person in conjunction with an average 2-liter (0.5-gallon) per day water ingestion rate is standard for risk assessment. People with smaller mass would be expected to have correspondingly less water intake per day. Since the reference dose is given as milligram of uranium (ingested in drinking water) per kilogram of body mass per day, as long as water intake and body mass are correlated the actual mass of the body is not an issue.

DOE believes that information provided in the EIS on use of acceptable models and parameters is consistent with the National Environmental Policy Act and sufficient to support the Secretary of Energy's determination whether to recommend development of the Yucca Mountain site as a repository.

7.5.7 (12075)
Comment - EIS002311 / 0004
Section 5.10 of the 1999 DEIS is arguably incorrect about the following: "The number of cancer fatalities that would normally occur each year in the population in the Amargosa Valley (assuming a population of about 1,150 persons) would be about 2. This number is based on approximately 163 cancer fatalities per year per 100,000 population for males in the United States (NIH 1999). This comparison clearly indicates that the human health impacts associated with the Proposed Action would be very small for the population in general." These statements are incorrect because: 1) the EIS bases the result of 2 fatalities per year on statistics that only monitored males, ignoring the other 50% of the population; and 2) the last sentence, "This comparison clearly indicates that the human health impacts associated with the Proposed Action would be very small for the population in general," assumes that in order to suffer from a "human health impact," a person must die.

Response
DOE has revised the EIS to use cancer incidence statistics for the entire Nevada population. The average annual mortality rate for cancer deaths per 100,000 persons in Nevada is 201.7, compared to a national rate of 200.3 (DIRS 153066-Murphy 2000). In addition, DOE has added information to note that cancer accounts for 23.2 percent of all U.S. deaths annually (DIRS 153066-Murphy 2000). However, even using this updated information, the annual number of expected cancer deaths in a population of 1,150 would still be 2.

DOE believes that no adverse radiation-related health effects from Yucca Mountain activities would be likely. The estimated levels of radiation exposure from Yucca Mountain operations would be very low – less than 2 millirem per year for the highest annual exposure (see Sections 4.1.2, 4.1.7, 5.4, and 5.10 of the EIS).

Because estimated radiation exposures would be so low, the occurrence of stochastic effects would be the principal risk from exposure to low levels of ionizing radiation. Stochastic effects include latent cancer fatalities, nonfatal cancers, and hereditary disorders. They have a probability of occurrence, with no threshold or minimum amount of radiation dose that must be received before they could occur. The International Commission on Radiological Protection (DIRS 101836-ICRP 1991) and the National Council on Radiation Protection and Measurements (DIRS 101857-NCRP 1993) have published radiation risk factors for these effects, which DOE has accepted for use in the

EIS. Nonfatal cancer and hereditary disorders would be 20 percent and as much as 26 percent, respectively, of the fatal cancer risk, which is 0.0005 per rem. Since the risk of these stochastic nonfatal effects would be about one-fourth or less of the fatal cancer risk, DOE only presented the estimates of fatal cancer risk. DOE has revised the radiation health primer in Section F.1 of the EIS to provide updated information.

7.5.7 (12178)
Comment - 010364 / 0004
The PBPK modeling is an important tool for improving the accuracy of human health risk assessment for hazardous substances in the environment. The proper use of PBPK model can reduce the uncertainties that currently exist in risk assessment, and provide more scientifically credible extrapolations across species, routes of exposure, metabolism and exertion. The PBPK modeling helps to identify the factors that are most important in determining the health risks associated with exposure to chemicals. The PBPK model provides a mean for estimating the impact of these factors both on the average risk to population and a specific risk to an individual [Clewell] (Celwell H.J., Toxicol. Lett. 79:207-217, 1996).

Response
Because of the reasons cited in this comment, the Physiologically Based Pharmacokinetic (PBPK)-based internal dosimetry models recommended by the National Council on Radiation Protection (DIRS 101882- and 101883-NCRP 1996) and the International Commission on Radiological Protection (DIRS 101075-ICRP 1977) have been used in this EIS to estimate potential radiation dose. Although the use of PBPK models could be expanded to consider impacts from all chemical forms, the resulting effects from exposure to both radionuclides and heavy metals estimated for the EIS are quite small (see Chapter 5 for details). Thus, it is unlikely that the use of alternative models would increase the estimated effects or add meaningful information to the decisionmaking process.

7.5.7 (12179)
Comment - 010364 / 0005
There is extensive literature review concerning interactions between wide range of metals, and radionuclides. However DOE-YMP management has not addressed the potential interactions between specific radionuclides, heavy metals and neutron poisoning elements.

Response
Although there is literature regarding complex interactions between metals and radionuclides, it is largely research information that is not currently contained in consensus modeling. The models used in this EIS could be expanded to consider impacts from all chemical forms; however, the effects from exposure to both radionuclides and heavy metals estimated for the EIS would be quite small. Thus, it is unlikely that the use of alternative models would increase the estimated effects or add meaningful information to the decisionmaking process.

7.5.7 (12181)
Comment - 010364 / 0002
In spite of the governmental, professional and quasi-governmental organization recommendations to the YMP [Yucca Mountain Project] management, they did not address all issues of complex mixtures in their Environmental Impact Statement (EIS) (Yucca Mountain Project Environmental Impact Statement Draft Proposal Appendix H-l, August 1999). This should have addressed complex mixtures including heavy metals found in the C-22 metal canisters such as (U [uranium], Mo [molybdenum], Cr [chromium]); neutron poisoning substances; (B [boron], Cd cadmium], Ce [cerium], Gd [gadolinium]) used for shielding in canister; and the long-lived radionuclides (Tc [technetium]-99, I [iodine]-129, Np [neptunium]-237, U-234, Pu [plutonium]-239, and Pu-242). Neither did they fully incorporate the tritium groundwater plume generated as a result of 260 underground nuclear explosions at the Nevada Test Site. The Yucca Mountain environmental impact statement ignored the use of a Physiologically Based Pharmacokinetic Model (PBPK) model, which is advocated by the EPA [Environmental Protection Agency] and the environmental community to assess the impact of complex mixtures.

Response
The EIS discusses the risks of exposure to ionizing radiation and hazardous chemicals separately where such exposures could exist. A good scientific foundation for adding the risks of exposure to radiation and chemicals does not currently exist, even if target tissues might be the same, because exposure pathways and cellular and molecular mechanisms of cancer induction can differ.

The inventory of chemically toxic materials that would be emplaced in the repository under the Proposed Action is identified by element in Section I.3 of the EIS. Based on this inventory, a screening analysis (described in Section I.6.1) identified which of the chemically toxic materials might pose a risk to human health. Only chromium, molybdenum, nickel, and vanadium were identified as posing such a risk, and these elements were further evaluated in a bounding consequence analysis, as described in Section I.6.2 (see Table 5-14 for results). This bounding analysis shows that the concentration of chromium, molybdenum, nickel, and vanadium in well water is calculated to be below the Maximum Contaminant Level Goal or yield intakes well below the Oral Reference Dose. Based on Environmental Protection Agency guidance (51 *FR* 34014; September 24, 1986), since the Hazard Index (sum of the Hazard Quotients) of these contaminant intakes is much less than unity, DOE believes that adverse health impacts resulting from consumption of such concentrations would be unlikely.

While it is not possible to scientifically address all of the research issues associated with complex mixtures of radionuclides and heavy metals at this time, it is possible to use consensus modeling approaches and assumptions for supporting the decisionmaking process associated with National Environmental Policy Act assessments. These research issues include potential synergistic effects from such exposures, and because they are research issues, there is currently no consensus modeling approach. Because the resulting effects from exposure to both radionuclides and heavy metals estimated for the EIS are quite small, DOE believes that it is unlikely that the inclusion of synergistic effects would add meaningful information to the decisionmaking process.

For the case of the tritium groundwater plume, because tritium has a 12.3-year half-life, and because of the long holdup times estimated for the proposed repository (thousands of years), it is not physically possible for these two plumes to interact because the tritium would be effectively decayed away within a few hundred years. Finally, the internal dosimetry models applied in the EIS are Physiologically Based Pharmacokinetic (PBPK) models, which use human metabolic data to describe the internal transport and deposition of radionuclides in bodily organs.

7.5.7 (12184)
Comment - 010364 / 0001
Several models for the action of mixed irradiation with two types of radiation have been proposed in the last two decades, but YMP management failed to include them in the EIS. Mixed irradiation is sometimes composed of more than two types of radiation, and for this type of mixed irradiation, no model has yet been proposed. It is of importance to assess the effect of mixed irradiation in terms of the environment, groundwater contamination, transportation accidents, space, and medicine.

Response
The models suggested by the commenter are based on limited research data and are generally applied to mixtures of low LET (photon) and high LET (neutron or alpha) radiation, in terms of cell death at high dose rates. The impact of interest to the long-term assessment of potential human health effects from the Proposed Action is the induction of latent cancer fatalities, not cell death. For potential cancer induction at low dose rates, the dose conversion factors and risk coefficients used for the EIS analysis (see Section F.1.1.5) are consistent with recommendations from national and international scientific advisory groups, and assume additive cell responses from mixed radiation. Although synergistic responses from mixed radiation (that is, where the combined effects are greater than the additive response) have been postulated, this is of research interest only at this time. In fact, one of the papers cited by the commenter (Suzuki, S. Radiation Research Society, 0033-7587/94, pp. 297-301) concludes: "...there has been no evidence for synergism of mixed irradiation..." and the terms synergism and synergistic should also not be applied to mixed irradiation unless a reasonable definition and evidence are provided. Since the purpose of the EIS and of all National Environmental Policy Act evaluations is provide information to decisionmakers, DOE believes it is not appropriate to use research models that include potential synergistic effects from mixed irradiation. However, the Department continues to monitor these research activities and any future recommendations by the scientific advisory groups that might contain such considerations.

7.5.7 (12407)
Comment - EIS001888 / 0334
[Clark County summary of comments it has received from the public.] Commenters believed that the repository EIS should address public health and safety issues including -- baseline and future health assessments: past exposures to radiation; dangers of, radiation; releases of radioactivity; exposure pathways and scenarios- effects of radiation on Native Americans; agriculture; human error and nuclear proliferation.

Response
Chapter 8 of the EIS discusses the impacts of the repository, along with the impacts from past, present, and reasonably foreseeable future actions in the affected area. In preparing this chapter, DOE reviewed many documents to determine where there was potential for cumulative impacts. These documents included resource plans by land-management agencies, EISs, environmental assessments, strategic plans, records of tribal meetings, and other documents prepared by Federal, state, local, and private organizations. The analyses and results described in Chapter 8 consider only those impacts from activities that have the potential to coincide in time and space with impacts from the repository. Based on some of the comments received on the Draft EIS and more recent information on activities at the Nevada Test Site, DOE modified several analyses in the Final EIS. The Department believes that the Final EIS analyzes a sufficient range of past, present, and reasonably foreseeable future actions that could contribute to cumulative impacts.

As part of its analysis of cumulative impacts in Chapter 8, DOE quantified, where possible, the total radiation dose that local residents have received. The Department calculated the total risk to the population based on the assumption that radiation risks from different exposures are additive.

With respect to person-specific exposure, DOE cannot account for each resident's past exposure to radiation. To do so would require accounting for person-specific lifestyle and habits, such as the frequency of cross-country airline flights, past residences in locations that might have substantially higher or lower cosmic radiation, and the frequency and nature of medical diagnostic tests and treatments. Rather, the Department used population risk factors. These factors account for the variety of individuals in the population, including differences in risk due to age. An estimate of impacts to specific groups of people (such as pregnant women, children, the elderly, and certain ethnic groups) was not made because such estimates would have greater uncertainty. The doses that have been calculated thus far for downwind residents have uncertainty associated with them that would tend to overshadow differences in risk to the various groups cited. The use of the average risk factors adequately covers all groups within the population and gives a reasonable estimate of the risk to the group as a whole.

Section 8.3.2.1 of the EIS describes the activities on the Nevada Test Site that could contribute to cumulative impacts with the proposed repository. Section 3.1.8.2 estimates the annual radiation dose to a hypothetical individual in Springdale, Nevada, from airborne radioactive materials release during past testing of nuclear weapons at the Nevada Test Site. Since issuing the Draft EIS, DOE has revised some of the analyses of impacts associated with the Nevada Test Site. Sections 8.2.2.2 and 8.4.2.7 now include information on radiation exposure from past nuclear weapons testing, and Section 8.3 includes updated estimates of future impacts to groundwater and air resources from activities on the Test Site. In addition, Section 8.4.2.7 of the Final EIS now incorporates the human health impacts from the transportation activities discussed in Section 8.4 (for example, Table 8-58 describes radiological and nonradiological impacts from waste transport between 1943 and 2047). Section 8.3 estimates the long-term future impacts to groundwater from potential migration of radiological and hazardous contaminants from the repository, the Nevada Test Site, and the Beatty low-level waste site.

Section 3.1.8.2 mentions that DOE made quantitative estimates of the offsite doses from releases from past weapons testing at the Nevada Test Site. In response to public comments, Appendix J of the Final EIS now contains maps showing routes used in analyzing impacts, and estimates radiological and nonradiological impacts for each state. This is in addition to the route maps that were already included in the Draft EIS (see Section 2.1.3.2 for national routes and Section 2.1.3.3 for Nevada maps). Based on this information and analyses, DOE has concluded that the cumulative impacts of waste transport, past testing of nuclear weapons, and other Federal and private programs involving radioactive materials in the State of Nevada would not be significant.

Readers interested in further information about the effects of past testing of nuclear weapons should refer to Institute of Medicine and National Research Council (DIRS 152469-1999).

A discussion of the role of the project in nuclear nonproliferation has been added to Chapter 1 of the EIS. The text states that internationally, permanent geologic disposal is the consensus on management of commercial spent nuclear fuel. The United States remains committed to a once-through fuel cycle and to disposing of commercial spent nuclear fuel in a geologic repository. This policy assumes that fuel originating in the United States and used in foreign research reactors would be disposed of in a U.S. repository. This approach supports the U. S. advocacy for limiting international trade in weapons-usable nuclear materials and signals our commitment to a policy of nonproliferation of nuclear materials.

7.5.7 (12781)
Comment - 010104 / 0004
Section 3.1.7: How much heat loading will occupational workers be exposed to in the drifts and other underground locations?

Response
Heat stress is an occupational hazard of which DOE is well aware, and DOE's worker protection program at the repository would take all appropriate measures to make sure workers do not suffer from heat stress. The potential for "heat loading" of workers, presumably meant to mean heating from emplaced waste packages, would be very small. Workers would not be in the direct vicinity of emplaced waste packages. Occasionally, workers could need to perform inspection or maintenance activities in the ventilation air downstream from the emplacement drifts. This air could be of elevated temperature, as high as 58ºC (136ºF) (Section 4.1.2.3.1). All appropriate measures to prevent worker heat stress would be taken in these instances.

DOE believes that information provided in the EIS on protection of repository workers from heat loads is adequate.

7.5.7 (12830)
Comment - 010305 / 0006
Why is risk assessment assumed to be caused by the hundreds of elements, their daughters, cousins and aunts that are omnipresent radionuclides? Why isn't the toxicological effects of highly toxic heavy metals that are known carcinogens tested? If D of I gets involved how can this project comply with ALARA standards if the public, workers both past and present die from silicosis and other repertory diseases? Using GENII-S along with the linear threshold theory for cancer exposure is dead wrong because it doesn't take into account DNA complex breakdowns, which cause high rates of cancer. How many deaths are allowed?

Response
The assessment of risk to the public during the preclosure period when the repository is open and ventilation is occurring focuses upon the release of radon-222 and its radioactive decay products. These radionuclides account for greater than 99 percent of the total dose to the public (Sections 4.1.2 and G.2). Exposures of workers to silica dust would be kept below regulatory limits established by the Occupational Safety and Health Administration, preventing the occurrence of silicosis. Potential exposure of members of the public to silica dust is evaluated in Section 4.1.2, and shown to be extremely small with no potential for health impacts. The health impacts of heavy metals that could be released during the postclosure period are addressed in Chapter 5 and Appendix I. There would be no such releases during the preclosure period. All potential exposure by members of the public and workers to all of these substances would be below applicable regulatory limits in all cases, and kept as low as reasonably achievable (ALARA).

The GENII-S computer code does not incorporate the linear no-threshold hypothesis, instead ending with the calculation of radiation dose received. The hypothesis is used as a basis for converting radiation dose to the estimated risk of latent cancer fatality. What exactly is meant by "complex DNA breakdowns" is not clear; however, the effect of radiation on DNA and the potential for causing cancer is addressed. The linear no-threshold hypothesis is the accepted national and international basis for estimating the risk from radiation exposure. Many radiation protection professionals now believe that this hypothesis is too conservative and there is some scientific evidence to support this viewpoint. Other individuals believe the hypothesis is nonconservative, but have little scientific evidence. Regardless of these other viewpoints, DOE has chosen to use the accepted national and international standards in estimating the risk of radiation exposure. In all cases the estimated radiation exposure to individual members of the public is very small. When summing these very small individual risks over an exposed population over the lifetime of the project, there is a calculated estimate of one or two latent cancer fatalities occurring. These impacts are discussed in Section 4.1.7.5 of the EIS.

7.5.7 (12907)
Comment - 010314 / 0015
What analyses were made of the potential impacts of escaped radioactivity on humans and other animals, and on plants and other living creatures if a lower-temperature operating mode is chosen that would defer the emplacement of the fuel into the repository for some decades and instead store the casks above ground?

Response
The potential impacts of using surface aging of spent nuclear fuel as part of the lower-temperature operating mode is examined fully in the Final EIS. There would be no "escape" of radionuclides from storage containers on the aging pads, since these containers would be sealed. Some gamma and X-ray radiation emitted from the fuel would penetrate the storage containers; workers or animals in the immediate vicinity could receive a dose of external radiation. Potential impacts to workers are considered in Section 4.1.7 of the Final EIS. All workers would receive radiation doses less than the regulatory limits and as low as reasonably achievable. Potential impacts to plants and animals are examined in Section 4.1.4. Potential radiation doses would be well below the threshold of impacts to these organisms. Potential impacts of accidents are considered in Appendix H. Accidents to storage containers on the aging pads was evaluated and determined to be an incredible event.

7.5.7 (13072)
Comment - 010248 / 0004
Estimates of the radiological impacts of the flexible design require additional technical basis.

Basis
The SDEIS (U.S. Department of Energy, 2001a, Section 3.1.7) states that "[e]xposed workers include both radiation workers and some general employees.... DOE used the total number of exposed worker-years to estimate potential impacts from the radiation dose received from this exposure, namely the number of latent cancer fatalities...." The SDEIS does not define the number of general employees, the lengths of their exposures, or the exposure levels associated with different phases of operation that were applied in estimating latent cancer fatalities.

In addition, the lower-temperature design option may require preclosure ventilation for a period beyond 300 years. Ensuring that the emplacement drifts remain clear and unobstructed from rockfall or drift collapse during this period is therefore important. The SDEIS does not appear to address the impacts of drift support system maintenance on worker exposure.

Recommendation
The FEIS should provide a more complete assessment of the radiological impacts of the flexible design, including maintenance activities associated with an extended preclosure period.

Response
In the Supplement to the Draft EIS total worker years are used as a primary impact indicator for occupational health and safety impacts. As noted on page 3-1, "The Department used the ratio of primary impact indicators to specific impacts in the Draft EIS to determine the Supplement impact estimates." Therefore, in the analysis the base ratio of involved (including radiation workers) workers to noninvolved (including general employees) workers was the kept the same as for the Draft EIS. The exposure [dose] levels used were the same as described in Appendix F of the Draft EIS. The total dose to each of these worker populations was changed accordingly for the total length flexible design being considered as compared to the Draft EIS high thermal load scenario. The additional time needed for repository monitoring and maintenance was included in the Supplement estimates. A complete analysis of worker impacts under the flexible design operating modes is presented in Section 4.1.7 of the Final EIS. Section 4.1.7.5 shows that over the duration of the project construction, operation and monitoring, and closure phases the dose to the maximally exposed worker is about the same as shown for the thermal load scenarios in the Draft EIS.

7.5.7 (13235)
Comment - 010244 / 0034
The fuel would arrive in a variety of transportation casks due to size and types. Commercial spent nuclear fuel would arrive as individual assemblies and placed into transportation casks or in dual-purpose canisters that would have to be opened. The Supplement fails to address the consequences of extra handling.

Response
As noted on page S-2 of the Supplement to the Draft EIS: "This supplement focuses on modification to the repository design and operating modes addressed in the Draft EIS; it does not analyze aspects of the Proposed Action that have not been modified, such as the transportation of spent nuclear fuel and high-level radioactive waste, or the No-Action Alternative. DOE will address the Proposed Action and the No-Action Alternative fully in the Final EIS."

7.5.7 (13379)
Comment - 010182 / 0020
Furthermore, how does keeping and repackaging the waste packages above ground protect the public and environment?

Response
Repackaging waste materials into disposal packages in surface facilities at the proposed repository is necessary to ensure long-term performance. However, radiation exposures from these activities are expected to represent less than one percent of the radiation exposure to the public from all other activities. Radon-222 and its decay products account for 99 percent of the radiation dose to the public from repository activities, because only very small quantities of man-made, noble gas radionuclides would be released from spent nuclear fuel handling activities (Section G.2.3.2).

DOE recognizes that the risk of cancer and other health effects caused by exposure to ionizing radiation is of concern to many citizens. Thus, in addition to keeping radiation doses within Environmental Protection Agency *Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada* (40 CFR Part 197), and Nuclear Regulatory Commission licensing criteria (10 CFR Part 63), DOE is also committed to keeping radiation doses from Yucca Mountain-related preclosure activities to levels that are as low as is reasonably achievable. For example, in the vicinity of the repository (the area within 50 miles), DOE estimates short-term impacts from construction, operation and monitoring, and closure of the proposed repository would result in less than 2 millirem per year to the maximally exposed member of the public (see Table 4-35 of the EIS). This exposure is less than 15 percent of the 15-millirem limit promulgated at 40 CFR 197.4 and 10 CFR 63.204 and less than 1 percent of the annual 200-millirem dose to members of the public in Amargosa Valley from background levels of naturally occurring radon-222 and its decay products. For the flexible design, for the first 10,000 years after repository closure, the mean peak annual receptor dose to the reasonably maximally exposed individual would be more than 100,000 times less than the individual protection standards at 40 CFR 197.20 and 10 CFR 63.311, which allow up to 15-millirem-per-year dose rates during the first 10,000 years (see Table 5-6). The peaks would be even smaller at greater distances.

The EIS also provides estimates of lifetime doses and additional fatal cancers for entire populations that could be affected by the Proposed Action. For example, DOE estimates that for the lower-temperature operating mode, the potentially affected population within 80 kilometers (50 miles) of the repository (estimated to be 76,000 individuals in 2035), could receive as much as 4,000 person-rem over 341 years of operation that could result in as many as 2 additional cancer fatalities in the exposed population. This would represent an increase of 0.002 percent of the 89,000 cancer deaths expected to occur from natural causes in the potentially exposed populations over a 340-year period (that is, five 70-year generations). This would represent an increase of 0.002 percent of the 89,000 cancer deaths expected to occur from natural causes in the exposed populations over a 340-year period. Similar estimates have been made for impacts to populations exposed over 10,000 years (see Table 5-7).

Although low levels of radiation exposure are estimated to result from the proposed action to construct, operate and monitor, and close the proposed geologic repository and the EIS provides estimates of latent cancer fatalities that could result from these small doses, these estimates are provided primarily to inform the decisionmaking process by enabling a quantitative comparison of impacts between the alternatives evaluated in this EIS. In all cases, estimates of latent cancer fatalities resulting from very small doses summarized in the EIS should be viewed as conservatively high; in fact, the uncertainties and conservatisms associated with these estimates (see Sections K.4.3.2 and F.1.1.5) are such that DOE believes that any adverse health impacts resulting from these exposures would be highly unlikely or nonexistent.

7.5.7 (13484)
Comment - 010260 / 0008
The exclusion zone needs to be expanded to more adequately protect the surrounding residents.

Sand filters need to be used in all ventilation shaft locations throughout the facility. The greatest technological measures need to be taken to ensure worker safety and the prevention of radioactive releases to the surrounding region. HEPA [high-efficiency particulate air] filters are not an adequate alternative. We are interested in how these filters will be disposed when their effectiveness expires.

Response
Potential impacts of accidents at the repository are examined in Section 4.1.8 and appendix H. These analyses indicate the area of land withdrawal and level of filtration on repository facilities provides adequate protection for members of the public from credible repository accidents. Some surface facilities, such as the Waste Handling Building, would use high-efficiency particulate air filters; the subsurface repository would not unless a release was detected. The filters would capture nearly all of the particulate radionuclides that are the main concern for dose to the public. The filters would not capture noble gas radionuclides. The main radionuclide that would be released from the subsurface repository during routine activities would be naturally occurring radon-222, also a noble gas, and neither high-efficiency particulate air nor sand filters would provide effective control of radon-222. In fact, sand filters are not considered to be a practical alternative for filtering of radionuclides at the repository or at other nuclear facilities.

7.5.8 AESTHETICS

7.5.8 (1368)
Comment - EIS000375 / 0003
The air quality in this part of the United States and visual acuity to see the moon and the stars is very high. This is a covenant resource that we oftentimes don't consider of value, but it is of value. Dark nights where astronomers can view stars, as well as the public can enjoy stars, is an important resource to Death Valley National Park.

We believe -- I haven't read it anywhere -- but we believe as a fairly safe presumption that given a 10,000-year security plan, which, again, I find a little hard to comprehend, will result in fences, guards, bright lights, somewhat similar, as has been mentioned in other ways, to a maximum security prison. Yucca Mountain is only 12 miles from Death Valley. We believe that will be an imposition on the scenic resources of Death Valley National Park, particularly at night. We believe that this project, if that is true, would significantly decrease this desert quality.

Response
DOE would provide night lighting at the proposed repository. This lighting could be visible from public access points to the south many miles from the repository. Ventilation stacks along the crest of Yucca Mountain could be visible if lighting atop the stacks was required. The effects of lighting from the repository would likely be less than the effects of light emanating from towns between the repository and Death Valley (Beatty, Amargosa Valley, and Pahrump). The lights from Las Vegas are most likely the dominant contributors to night lighting in southern Nevada. DOE has added a discussion of nighttime darkness as a resource around Yucca Mountain to Section 3.1.10 of the EIS. Outdoor night lighting at the Yucca Mountain Repository would be shielded and directed downward where possible.

7.5.8 (8091)
Comment - EIS000406 / 0011
The following issues need to be addressed and thoroughly analyzed concerning direct impacts to Lander County in a detailed manner:

Aesthetics effect

Response
The Carlin Corridor, one of five candidate rail corridors considered by DOE in Section 6.3 of the EIS, would pass through Lander County. About 85 percent of the 400-meter-wide (1,300-foot-wide) corridor crosses public land administered by the Bureau of Land Management. As a consequence, DOE used the Bureau's visual management